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VOLUME I

PREDICTIVE OPERATIONS AND MAINTENANCE COST MODEL

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Air Force Avionics Laboratory
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This technical report has been reviewed and is approved for publication.

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This report describes a model which can be used to estimate the operations and support costs of avionics line replaceable units (LRU's). The model relates available LRU design parameters to operations and support costs using various cost estimating relationships. This document is Volume I of the final report which describes the development of the revised version of the Westinghouse Avionics Laboratory Predictive Operations and Support (ALPOS) cost model developed in 1977-1978 and described in AFAL-TR-78-49. This revised version, known as ALPOS II, has a more expansive data base than ALPOS and includes digital avionics systems not included in ALPOS. The Air Force Program Monitor was Mr. Daniel V. Ferens, System Evaluation Group (AFAL/AAA-3), Avionics System Engineering Branch.

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PREFACE

This document is Volume I of the Final Report concerning the development, in two phases, of the Avionics Laboratory Predictive Operations and Support Model (ALPOS) by the Logistics Engineering Group, Westinghouse Integrated Logistics Support Division. The Phase I efforts, begun in June 1977, have been described in reports dated April 1978. So that the entire effort could be presented in a comprehensive manner without the need for continued reference to the previous reports, this document includes pertinent information from the first phase as well as a detailed discussion of the second phase enhancement effort. This enhancement, which commenced in July 1978, focused on the need for collection of additional data with refinements to the data analyses and the model. The accompanying Volume II presents a detailed discussion of the mathematical and statistical techniques used in the multiple regression analyses for Phase II estimating relationships. The Authors wish to acknowledge the assistance of the personnel in AFAL/AAA-3, AFLC/LOMA, AFLC/LOLR, HQ USAF/ACMC and the many Air Logistics Centers and Air Force Base organizations visited. Also, the Authors wish to acknowledge the technical contributions to this effort made by Nancy Orndorff, Jack Pessin and Jack McCartney. Also acknowledged is the data reduction and computer programming contributions of Tom Beers, Theresa Wallace, Debbie Saidman and Ken Whitfield.

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LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

ABBREVIATION	MEANING
ADTS	Automatic Depot Test Set
AFAL	Air Force Avionics Laboratory
AFB	Air Force Base
AFLC	Air Force Logistics Command
AFLCP	Air Force Logistics Command Pamphlet
AFM	Air Force Manual
AFTO	Air Force Technical Order
AGE	Aerospace Ground Equipment
AGMC	Aerospace Guidance and Metrology Center
AIS	Avionics Intermediate Shop
ALC	Air Logistics Center
ALPOS	Avionics Laboratory Predictive Operations and Support
ATC	Air Training Command
ATE	Automatic Test Equipment
AWACS	Airborne Warning and Control System
BIT	Built-In-Test
BITE	Built-In-Test-Equipment
BOS	Base Operating Support
CAIG	Cost Analysis Improvement Group
CBS	Cost Breakdown Structure
CDC	Control Data Corporation
CER	Cost Estimating Relationship
COMETS	Computer Operated Multi-Function Electronics Test Station
CONUS	Continental United States
COSPERANK	Cost and Performance Ranking
DoD	Department of Defense
EBO	Expected Backorder
ECM	Electronic Counter Measures
EM	Electro-Mechanical
FIT	Fault-Isolation-Test
FY	Fiscal Year
GPATS	General Purpose Automatic Test System
IBM	International Business Machines
IDA	Institute for Defense Analysis
IFF	Identification Friend or Foe
ILS	Integrated Logistics Support
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
IPB	Illustrated Parts Breakdown
IROS	Increased Reliability of Operational Systems

LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS (Continued)

ABBREVIATION	MEANING
LCC	Life Cycle Cost
LLSCFP	Linear Least-Squares Curve Fitting Program
LSC	Logistics Support Cost
LSC/OH	Logistics Support Cost per Operating Hour
LSI	Large Scale Integration
LRU	Line Replaceable Unit
MAC	Military Airlift Command
MADAR	Malfunction Detection, Analysis, and Recording
MBO	Management By Objective
MDCS	Maintenance Data Collection System
MDS	Mission Design Series
MED	Micro Electronic Device
MIL-STD	Military Standard
MIT	Massachusetts Institute of Technology
MMH	Maintenance Man-Hours
MMH/OH	Maintenance Man-Hours per Operating Hour
MMH/FH	Maintenance Man-Hours per Flight Hour
MRA&L	Manpower Readiness Acquisition and Logistics
MSI	Medium Scale Integration
MTBF	Mean-Time-Between-Failures
MTBMA	Mean-Time-Between-Maintenance-Actions
MTTR	Mean-Time-To-Repair
NRTS	Not Repairable This Station
NSIA	National Securities Industries Association
NSC	National Stock Class
NSN	National Stock Number
OAS	Offensive Avionics System
OASD	Office of the Assistant Secretary of Defense
O&S	Operations and Support
ORLA	Optimum Repair Level Analysis
OSCER	Operations and Support Cost Evaluation Reports
PER	Parametric Estimating Relationships
PMD	Program Management Directive
PRICE	Programmed Review of Information for Costing and Evaluation
PS	Power Supply
QPA	Quantity per Assembly
RCS	Report Control Symbol
RF	Radio Frequency
RRMS	Residual Root Mean Squared

LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS (Continued)

ABBREVIATION	MEANING
SAC	Strategic Air Command
SPSS	Statistical Package for the Social Sciences
SRA	Specialized Repair Activity
SRU	Shop Repairable Unit
SSI	Small Scale Integration
TAC	Tactical Air Command
TO	Technical Order
TRC	Technological Repair Center
UCLA	University of California at Los Angeles
VAMOSC	Visibility and Management of Operations and Support Costs
VHSI	Very High Speed Integration
VLSI	Very Large Scale Integration
WBS	Work Breakdown Structure
WS	Weapon System
WUC	Work Unit Code

SECTION I

INTRODUCTION

Long term DoD planning goals assume a decrease in weapon systems operations and support (O&S) costs.(1) Unless the past trend of rising O&S costs can be reversed to meet this goal, funds will need to be siphoned from an already austere procurement budget. This issue can be described in one word - "affordability".(2) All weapon systems managers are challenged by the need for affordability when evaluating alternatives for performing a mission. This translates into balancing both reduced acquisition and O&S costs with improved reliability and acceptable military performance.

The costs of O&S comprise a large portion of Life Cycle Costs (LCC) which can be defined as the research and development, acquisition, operations and support, and disposal costs for a system. This definition is from the National Securities Industries Association (NSIA) Ad Hoc LCC Committee report to the Assistant Secretary of Defense (Installations and Logistics).(3) In recent years the cost of operations and maintenance for many systems has exceeded that of procurement. When the acquisition logistics costs included in procurement costs are considered, the value of support compared to system acquisition is quite large. In FY 1974, operations and maintenance was 27% of the total DoD budget while procurement was 20% of the DoD budget. These totals do not include Military personnel, 28% of the DoD budget, so the actual differences would be much greater than seven percent.(4) For example, other references estimated operations and maintenance costs to be 2 1/3 times acquisition cost.(5) Even when recent advances in support technologies which have reduced support costs are considered, the cost of operations and maintenance is still a large part of DoD's expenditures. Thus in order to attain DoD planning goals it is important that they be given detailed consideration in every decision milestone in the

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(1) "Zero Growth" memorandum, Deputy Secretary of Defense Clements, 28 February 1976

(2) The Affordability Problem, Dale W. Church, Deputy Undersecretary of Defense for R&E, Logistics Spectrum, Winter 1978

(3) Report of the NSIA Ad Hoc LCC Committee, June, 1976

(4) Electronics - X: A Study of Military Electronics with Particular Reference to Cost and Reliability, Volume 2, Howard P. Gates et al, IDA, Arlington, Virginia, January, 1974

(5) Life Cycle Costing Implementation, Raytheon Corporation, no date

procurement of major weapons systems as well as source selection. This is emphasized in DoD Directive 4105.62, Selection of Contractual Sources for Major Defense Systems, 6 January, 1976, which requires use of LCC as the criteria in evaluating contractors. A new thrust in this area is the "design to affordability" concept now being formulated within the DoD. Part of this concept deals with estimating LCC for alternate system concepts during the Defense System Acquisition Review Council (DSARC) milestone "0". In the particular field of avionics the recently issued Air Force Policy on Avionics Acquisition and Support, AFR 800-28, 11 September 1978, also addresses the need to "emphasize LCC early in avionics development programs and as a prerequisite for all program decisions". The reduction of LCC for future avionic systems is the driving function for the research and development tasks being undertaken by the Air Force Avionics Laboratory.(6) These tasks are not only concerned with the R&D of advanced hardware and software technologies, but the development of techniques that can be used to assess the impact of design and technology alternatives on LCC.

Early visibility of potentially excessive costs are required since as much as seventy percent of the system LCC is determined by the end of concept studies as depicted in Figure 1.(7)

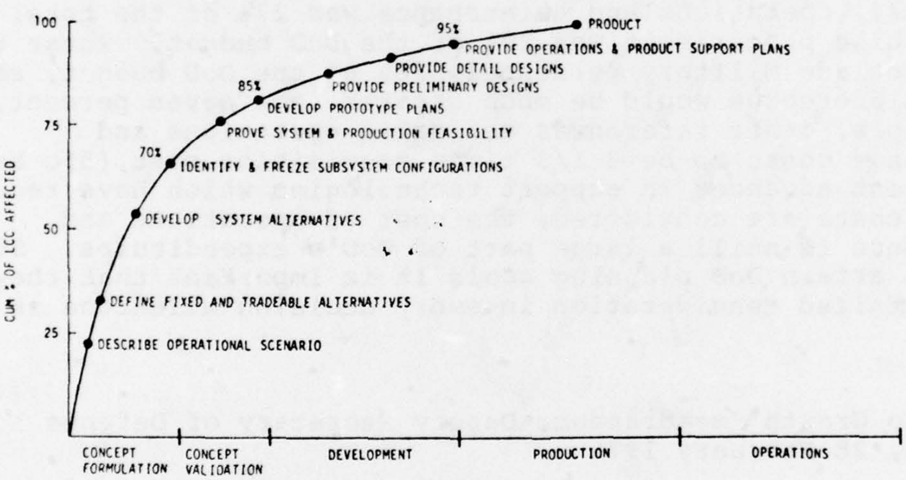

Figure 1. Actions Affecting LCC

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(6) Avionics Technology Thrusts for 1980-1985 AFAL Briefing to Industry, 17-18 January 1978

(7) The NSIA "Life Cycle Costing Study" Findings - A Candid Overview, Donald R. Earles, Life Cycle Costs Conference, Spring 1977

The realization of this fact mandates that techniques to predict LCC be available in the conceptual phase. Because system definition is not complete enough in this phase to perform detailed analysis using accounting models, the major tool which can be used is the parametric estimating model. This model relates the available design parameters to LCC via various Cost Estimating Relationships (CERs). This report describes the development of such a model for the Air Force Avionics Laboratory, the Avionics Laboratory Predictive Operations and Support (ALPOS) model.

The use of parametric estimating to predict acquisition costs is an established technique. Many manufacturers have developed models to estimate production costs. These models vary from single parameter estimates, using an independent variable such as unit price, to more complex estimates using a large number of independent variables, such as the RCA PRICE (Programmed Review of Information for Costing and Evaluation) Model.(8) A similar set of generalized models for estimating operation and maintenance (or support) costs does not exist, although several notable efforts have been made in this direction.

The estimating relationships previously developed for the Avionics Laboratory (9) use a limited number of parameters to estimate cost, two maximum, and do not estimate Mean Time Between Failure (MTBF) or Maintenance Manhours Per Operating Hour (MMH/OH). The RCA PRICE-LCC Model does have estimating relationships to estimate MTBF and Mean Time To Repair (MTTR), but maintenance costs are calculated using accounting techniques.(10) There are a number of reasons for this situation. The first major reason is that each contractor has detailed costs information on the costs to produce a hardware item. This is because the contractor is required to collect this data following a detailed Work Breakdown Structure (WBS). The accounting systems used by contractors are also structured to facilitate the collection and segregation of cost. In the areas of operations and maintenance, the costs are incurred by a large number of organizations, each with responsibility for many systems or subsystems. It is harder to segregate costs in this environment. The expense of collecting data to a detailed Cost Breakdown Structure (CBS) level from operational and support

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(8) PRICE Reference Manual, RCA, no date

(9) Cost Analysis of Avionics Equipment, E. N. Dodson et al, General Research Corporation, Santa Barbara, California, AFAL Report Number AFAL-TR-73-441, Volume I, February, 1974

(10) Reference Manual, PRICE Life Cycle Cost Model, August, 1977, RCA/PRICE Systems, Cherry Hill, New Jersey

elements could not be justified by the expected return. The second major reason is that it is easier to estimate the costs of producing new technologies, where no historical data base exists, than on the cost to support these technologies. This is because some experience is usually available even if only at the laboratory or pilot production level, from which cost data can be derived. Consequently, the challenges of this study were to review the existing data base and identify those elements and techniques which could be used to estimate O&S costs and, more specifically, maintenance costs. These challenges had to be met in order to have a useful operating and support cost estimating technique.

The model described in this report was developed in two phases to provide the Air Force Avionics Laboratory with the capability to predict avionics operations and support costs in the conceptual/early design phases. In the context used here, support includes maintenance plus the ancillary efforts to support the maintenance. The approach was to analyze existing data, determine what elements of LCC are pertinent to the model, and develop cost equations, using regression analyses and other techniques, for these cost elements. The analysis of existing data identified what data is available in various data systems, the areas where this data is insufficient or obsolete for estimating costs, and alternative data and techniques for estimating costs. Each of the cost elements associated with LCC was investigated to determine its influence on total costs. If a cost element was determined to have little influence on LCC it was dropped in order to reduce or eliminate bias in the model. This was done because the uncertainty and variation associated with cost estimates would have a greater effect than the cost estimates themselves if these uninfluential factors are retained. Appropriate cost and parametric estimating relationships were developed to predict the cost drivers. The development of these relationships was based on using the cost, logistics, and design parameters available from existing data systems. Since experience shows that support costs are mainly dependent on Mean Time Between Maintenance Actions (MTBMA), this factor received special attention and is used to estimate a number of costs. Due to developments in support technologies, particularly in areas such as spares provisioning and test equipment, the data in these areas is obsolete and other methods are required to predict future costs. Thus methods other than regressions on historical data are required to develop valid estimating relationships. This model attempts to use the best method available to estimate each cost element.

SECTION II

APPROACH

The basic approach to the current stage of development of the Predictive Operations and Maintenance Cost Model was to identify candidate Line Replaceable Units (LRUs) for inclusion in the data base, to collect data on design and logistics parameters on these LRUs, to perform regressions analysis on the data, and to use the resulting cost and parametric relationships to construct the model. Following a review of the results obtained in the first phase effort, it was decided to enhance the model by significantly expanding the regression data base. This expansion was not only in the absolute number of LRUs, but in the number of aircraft represented in the data base as well as a relative increase in the number of LRUs having digital components. Also, the number of LRUs in the communications group, which was previously determined to be less than optimal, was increased. Whereas the first phase regression data base was comprised of over 60 LRUs, additional data collected in the second phase brought the combined total to over 12C LRUs. Other aspects of the model enhancement involved incorporating different independent and dependent variables, and applying statistical techniques to determine their impact on O&S cost and to obtain subsets of the estimating relationships which fit the data as "good" as the original set. The candidate LRUs identified at the beginning of each Phase for inclusion in the data base are shown in Tables 1 through 7. The basic objective of the selection process was to obtain a sample of LRUs across a broad spectrum of the avionics installed on operational aircraft. Based on information obtained from Air Force base and Air Logistic Center (ALC) personnel during the numerous site visits, the composition of the list of LRUs changed as data collection progressed. The LRU selection was constrained by the number of aircraft on which the LRU was installed and the availability of logistics data. At the beginning of the Phase II effort, it was determined that the actual field logistics data from new systems such as the A-10 and F-16 was still not available from significant quantities of aircraft over a sufficient time period (1 year). Consequently, it was not possible to include LRUs from these aircraft in the regression data base, although some LRU design characteristic data were obtained.

TABLE 1

COMMUNICATIONS LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE I

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
F4E	RT-793A	ASQ-19B	Receiver-Transmitter	71NAO	x	x
RF4C	RT-793A	ASQ-88	Receiver-Transmitter	71QU0	x	x
F15A	RT-967	ARC-109	Receiver-Transmitter	63AA0	x	x
F15A	RT-1063B	APX-101	Receiver-Transmitter	65AAO	x	x
B52H	Various	ARC-34	Receiver-Transmitter	63BAA	x	x
B52H	Various	ARC-34	Receiver-Transmitter	63CAA	x	x
B52H	RT-728	APX-64	Receiver-Transmitter	65BAA	x	x
B52H	R-761	ARC-58	Receiver	61BBA	x	x
KC135A	RT-728	APX-64	Receiver-Transmitter	65BAA		x
KC135A	Various	ARC-133	Receiver-Transmitter	63AFO		x
C5A	RT-967	ARC-109	Receiver-Transmitter	63AAO	x	x
C130E	RT-263	ARC-34	Receiver-Transmitter	63121		x
KC135A	Various	ARC-34	Receiver-Transmitter	Various	x	
C130E	RT-728	APX-64	Receiver-Transmitter	65BAA	x	
C130E	-	ARC-164	Receiver-Transmitter	63AAA		x

TABLE 2

NAVIGATION LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE I

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
F4E	AM-3734	ASN-46A	Amplifier, Computer	71B20	x	x
F4E	CP-805	ASQ-91	Ballistics, Computer	73530	x	x
F4E	RT-547	ASQ-19	Receiver-Transmitter	71LBO	x	x
F4E	MX-4839	ASN-63	Platform, Gyro Stab.	71H60	x	x
RF4C	RT-736	ASQ-88	Receiver-Transmitter	71PKO	x	x
RF4C	AM-2349	ASQ-88	Amplifier, P.S. RCVR	71PB0	x	x
RF4C	AM-4680	ASN-55	P.S. Leveling, Amplifier	71710	x	x
RF4C	PP-3869A	APN-159	Power Supply	724G0	x	x
RF4C	CP-779	ASN-56	Computer, Navigation	71G50	x	x
F15A	AM-6435	ASN-108	Amplifier, Electronic Control	71FA0	x	x
F15A	CN-1375	ASN-108	Gyroscope, Displacement	71FB0	x	x
KC135A	-	ARN-21	Receiver-Transmitter	71CA0	x	x
F15A	RT-1045	-	Receiver-Transmitter	71DA0	x	x
F15A	AM-6440	-	Amplifier, Electronic Control	71BD0	x	
B52H	-	ARN-67	Receiver	71ABE		x
B52H	RT-204	APN-69	Receiver	72AA1	x	
B52H	-	ARN-21	Receiver-Transmitter	71ADA	x	x
B52H	RT-274C	APN-89	Receiver-Transmitter	73DBA		x
B52H	-	ARN-32	Receiver	71ACC	x	x
B52H	-	ASQ-38	Amplifier	73CBQ	x	x
B52H	-	ASQ-38	Computer, AZ and EL	73CEN	x	x
B52H	-	ASQ-38	Receiver-Transmitter	73CFK	x	x
B52H	-	ASQ-38	Power Supply, +300V	73CAR	x	
B52H	AM-946	APN-89	Amplifier, Electronic Control	73DAH	x	x
B52H	-	MD-1	Amp, Astrotrack, Servo	73EBA	x	x
B52H	-	MD-1	Signal Amplifier	73EBF		x
F15A	R-1755	-	Receiver	71CA0	x	x

TABLE 2 (Continued)

NAVIGATION LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE I

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
KC135A	RT-274	APN-81	Receiver-Transmitter	72EAA	x	x
KC135A	AM-742	APN-81	Amplifier, Electronic Control	72ECA	x	x
KC135A	RT-204	APN-69	Receiver	72CBC	x	x
C5A	-	-	Measurement Unit, IMU	72BP0	x	x
C5A	-	-	Receiver, VHF Navigational	71JA0	x	x
C5A	-	-	Receiver-Transmitter	71LA0		x
C5A	-	-	Processor Data	72DN0	x	x
C5A	-	-	P.S., Thermal Control	72AC0	x	x
C130E	-	ARN-67	Receiver	7171A		x
C130E	-	ARN-21	Receiver-Transmitter	7131D	x	x
C130E	-	APN-59	P.S. Power Supply	72RF0		x
C130E	-	APN-59	Amplifier	72RB0		x
RF4C	CP-1060	APD-10	Computer	736J0	x	
B52H	-	-	Tach Generator	73DAU	x	
B52H	-	MD-1	Astrotracker	73EAK	x	
B52H	-	MD-1	Gyro, Vertical	73EAL	x	
B52H	-	MD-1	Power Supply, -900 VDC	73EBN	x	
C130E	-	APQ-115	Computer Command	72KD0	x	
C130E	-	APQ-115	P.S. Programmer	72KC0	x	
C5A	-	APS-42A	Gyroscope	7221B	x	
KC135A	-	APN-81	Vertical Gyro	72EHL	x	
B62G	R-626	ARN-31	Receiver	71ABC	x	
C130E	R-626	ARN-31	Receiver	71512	x	
B52H	RT-204	APN-69	Receiver	72AA1	x	

NOTE: A "-" signifies not applicable, i.e. not found in WUC books.

TABLE 3

SENSORY LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE I

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
F4E	C-8977A	-	Weapons Release Control	75930	x	x
F4E	CP-891A	APQ-120	Computer	74BD0	x	x
F4E	T-1050	APQ-120	Transmitter	74BF0	x	x
F4E	CN-1388	ASG-26	Gyro, Lead Computer	74810	x	x
RF4C	-	APR-25	Analyzer, Pulse	76A10	x	x
RF4C	-	AAD-5	Electronic Power Supply	77SA0	x	
RF4C	-	ALR-46	Signal Processor	76GA0		x
F15A	MX-9098	APG-63	Processor	74FF0	x	x
F15A	T-1208	APG-63	Transmitter	74FA0	x	x
F15A	PP-6682	APG-63	Power Supply	74FH0	x	x
F15A	-	APG-63	Antenna	74FU0	x	x
F15A	OT-58	ALQ-135	Amplifier, RF	76HA0	x	
B52G	-	ASG-13	Computer, Central Ballistics, Computer	74GCA	x	
B52H	-	ASG-21	Ballistics, Computer	74LDA	x	
B52H	-	ASG-21	Transmitter	74LGA	x	
B52H	-	ASG-21	Power Supply	74LN0	x	
B52H	CV-3015	AAQ-6	Flir Signal Proc.	77EC0	x	x
B52H	-	AAQ-6	Flir Turret Drive	77EE0	x	x
B52H	MX-9310	AVQ-22	STV Camera Electronic	77DCA	x	x
B52H	-	ASQ-151	STV Turret Drive	77DB0	x	x
B52H	T-1206	ALQ-117	Transmitter	76AEA	x	
B52H	T-1086	ALT-22	Transmitter	76LFD	x	
B52H	-	AAQ-6	Gimbal Assembly	77EBF	x	
B52G	PP-336	APR-9B	Power Supply	76EFA	x	
RF4C	-	ADV-2	Electrical Power Supply	77Z40	x	
RF4C	-	-	Tape Transport	763V0	x	

TABLE 4

POD LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE I

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
F4E		ASQ-153	Laser Control, Electronic	73CR0	x	x
F4E		ASQ-153	Two Axis Gimbal Assembly	73CG0	x	x
F4E		ASQ-153	Roll-Axis Take-Off	73CY0	x	
-	-	ALQ-119	Drive P.S. and TWT, High	-	x	
-	-	ALQ-119	Microwave Osc., Mid (source)	-	x	
-	-	ALQ-119	Forward Electrical Assembly	-	x	
-	-	ALQ-119	Output TWT, Mid (Alt)	-	x	
-	-	ALQ-119	Output P.S., Mid	-	x	

NOTE: In the regression analysis Pods were included in the Sensory Group.

TABLE 5

COMMUNICATIONS LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE II

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
F-15A	R-1789	ARC-109	Radio Receiver	63AGO		x
F-15A	C-9011A	-	Control Panel, Integrated Communications	63BC0	x	x
F-15A	C-9012	-	Control Panel, IFF	63BF0	x	x
F-15A	-	-	Computer, Transponder	65AB0	x	
F-15A	-	-	Computer, Interrogator	65BB0	x	
C-5A	-	-	Central Multiplex Adapter	55AL0		x
C-5A	-	-	Computer Digital, Madar	55AV0		x
C-5A	-	-	Data Retrieval Unit	55AY0	x	
C-5A	-	-	Exciter Receiver, HF/SSB	61AA0	x	x
C-5A	-	-	Amplifier/Antenna Coupler	61AC0	x	
C-5A	-	-	Panel, Control, HF/SSB	61AE0	x	x
C-5A	-	-	Transceiver, VHF Comm	62AA0		x
C-5A	-	-	Transceiver, UHF FM	62CC0	x	
C-5A	-	-	Crystal Reference Unit	62CE0	x	
C-5A	-	-	IF Amplifier Unit	62CG0	x	
C-5A	-	-	Audio Amplifier	62CJ0	x	
C-5A	-	-	Oscillator Unit	62CL0	x	
C-5A	-	-	Amplifier Mod Unit	62CN0	x	
C-5A	-	-	Electronic Unit, CDP1R	66AG0	x	
C-130E	C-2105	AIC-18	Intercom Set	64211		x
C-130E	C-2106	AIC-18	Control Panel	64212	x	
FB-111A	RT-882	ARC-123	Receiver Transmitter	61AA0	x	x
FB-111A	AM-4573	ARC-123	Amplifier, Power Supply	61AB0	x	x
FB-111A	C-7073	ARC-123	Control	61AC0	x	x
FB-111A	-	APX-78	Control, Radar Transponder	72AA0	x	x
FB-111A	RT-871	APX-78	Receiver-Transmitter	72AC0	x	x

TABLE 6

NAVIGATION LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE II

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
F-15A	-	ASK-6	Computer, Air Data	51EA0		x
F-15A	CP-1104	ASW-38	Computer, Flight Control	52AA0		x
F-15A	CP-1105	ASW-38	Computer, Flight Control	52AB0		x
F-15A	C-9014	-	Control Panel, Integrated Navigation	63BD0	x	x
F-15A	CN-1376	ASN-109	Inertial Measurement Unit	71AE0	x	x
F-15A	C-8849	ASN-109	Control-Indicator, Nav	71AK0	x	
F-15A	IP-1086	OD-60	Indicator, Multiple Air Nav	74JA0	x	x
F-15A	CP-1088	OD-60	Processor, Signal Data	74JC0	x	x
F-106	-	-	Amplifier-Interface	52GA1		x
C-5A	-	-	Control Panel VHF Nav	71JCE		x
C-5A	-	-	Computer-Primary, IDNE	72AE0	x	x
C-5A	-	-	Computer-Analog/ Digital	72CC0	x	x
C-130E	-	ARN-118	Receiver-Transmitter	71ZA0	x	x
C-130E	-	ARN-118	Digital/Analog Converter	71ZB0	x	x
C-130E	-	ARN-118	Control Unit	71ZD0	x	x
C-130E	-	ARN-131	Receiver-Processor	72BAA	x	
C-130E	-	ARN-131	Control-Display	72BAB	x	
F-111D	-	ARN-118	Receiver-Transmitter	71ZA0	x	x
F-111D	-	ARN-118	Digital/Analog Converter	71ZB0	x	x
F-111D	-	ARN-118	Control	71ZC0		x
F-111D	-	AYK-6	Computer, General Purpose	73EG0	x	x
F-111D	CV2492A	-	Converter-Multiplexer	73EPO	x	x
F-111D	MX-8131	AJN-16	Stabilizer Platform	73HA0	x	x
F-111D	CP-945	AJN-16	Navigational Computer	73HC0	x	x

TABLE 6 (Continued)

NAVIGATION LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE II

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
			Unit			
F-111D	C-7719	AJN-16	Battery Control Power Supply	73HD0	x	
F-111D	AS-2136	APQ-128	Antenna-Receiver	73KB0	x	x
F-111D	AM-4915	APQ-128	Amplifier, Power Supply	73KE0	x	x
F-111D	SN-519	APQ-128	Synchronizer-Transmitter	73KF0	x	x
F-111D	CP-917	APQ-128	Computer, Terrain Following	73KK0	x	x
F-111D	IP-1030	AYN-4	Indicator, Horizontal Display	73NA0	x	x
F-111D	MX-8751	AYN-4	Processor, Horizontal Display	73NB0	x	
F-111D	MX-8088	APN-189	Electronic Unit, Radar	73QB0	x	x
F-111D	IP-1764	-	Indicator, Digital Display	73SC0	x	x
F-111D	C-7890	-	Control, Computer	73SD0	x	
FB-111A	-	-	Computer, Central Unit	73EE0	x	
FB-111A	-	-	Navigation Display Unit	73EF0	x	
FB-111A	-	-	Computer, General Purpose	73EG0	x	x
FB-111A	CP-945	AJN-16	Navigation Computer Unit	73HC0	x	x
FB-111A	-	APN-185	Electronic Unit	73LA0	x	x
FB-111A	-	ASQ-119	Tracker Celestial Positioning	73MA0	x	
FB-111A	-	ASQ-119	Electronic Unit	73MB0	x	
FB-111A	R-843A	ARN-58	Receiver Unit	71CA0	x	x
FB-111A	RT-1127	ARN-84	Receiver-Transmitter	71EA0	x	
FB-111A	CV-3135	ARN-84	Converter	71EB0	x	
F-111A,E	-	AJQ-20	Ballistic Computer	73AD0	x	

TABLE 7

SENSORY LINE REPLACEABLE UNITS (LRUs) INVESTIGATED

IN PHASE II

MDS	TYPE	A/N	NOUN	WUC	ORIGINAL SELECTION	IN MODEL DATA BASE
F-15A	MX-9147	-	Processor, Radar Target Data	65BH0	x	x
F-15A	CP-1377	-	Lead Computing Gyro	74EB0		x
F-15A	R-1765	APG-63	Receiver, Radar	74FC0		x
F-15A	0-1620	APG-63	Oscillator-RF	74FJ0	x	x
F-15A	C-8894	APG-63	Radar Set Control	74FK0		x
F-15A	MX-9099	APG-63	Processor, Radar Data	74FQ0	x	x
F-15A	IP-1103	AVQ-20	Display Unit, Head-Up	74KA0	x	x
F-15A	CP-1111	AVQ-20	Processor Signal Data	74KC0	x	x
F-15A	CV-2899	AWG-17	Converter-Programmer	75AE0	x	
F-4E	OD-115	APQ-120	Indicator Control	74CA0		x
F-4E	OD-115	APQ-120	Indicator, Pilot	74CB0		x
F-4E	OD-115	APQ-120	Indicator, PSO, I/O	74CC0		x
F-106	-	-	Input-Output Unit	74FA1		x
F-111D	CP-938	APQ-130	Processor, Electronic	73PB0	x	x
F-111D	T-1084	APQ-130	Radar Transmitter	73PD0		x
F-111D	CV-2489	APQ-130	Signal Data Converter	73PF0	x	x
F-111D	PP-6059	APQ-130	Power Supply, LV	73PH0		x
F-111D	R-1549	APQ-130	Radar Receiver	73PK0	x	
F-111D	O-1492	APQ-130	Reference Signal Gen.	73PM0		x
F-111D	-	-	Programmer, Elect.	75CCA	x	
F-111D	R-1437	ALQ-94	Receiver, ECM	76KK0	x	
F-111D	AM-4850	ALQ-94	Amplifier, RF	76KJ0	x	
FB-111A	AM-4869	ASG-25	Amplifier Power Supply, Control	74ACB	x	
FB-111A	CP-955	APQ-134	Computer, TFR	73KA0	x	x
FB-111A	-	ASQ-119	Tracker, Celestial	73MA0	x	
FB-111A	-	ASQ-119	Electronic Unit	73MB0	x	
B-52H	-	ALQ-117	Transmitter	76AEA		x

NOTE: A "_" signifies not applicable, i.e. not found in WUC books.

The first step in choosing the LRU candidates was to identify those factors which affect support costs and the parameters in aircraft and avionics design which alter these factors. From experience and a review of the algorithms used in the various data systems, reliability, expressed as Mean-Time-Between-Maintenance-Actions, was identified to be the key cost driver. A related driver is the utilization of the system, i.e. the total fleet operating hours per time period. Together these drivers produce the number of maintenance actions per time period, which determines the resources required for support. Once reliability was identified as a key parameter, the factors which can affect reliability were investigated. These factors include items such as environment, utilization and stressing. A complete discussion of all of the parameters involved in model development is contained in Section IV, Data Base Description and Development. The first grouping of candidates was by aircraft mission. A review of various aircraft Mission-Design-Series (MDSs) shows that within a certain mission type, such as a fighter, most of the parameters which affect reliability are similar, but that they vary greatly between aircraft missions. A review of the various mission types shows that a majority of avionics is installed in three types; i.e., Bombers (B), Fighters (F), and Transports (C). In addition, the other mission types, such as an attack (A), electronic warfare (E), and trainer (T) aircraft, are very similar to one of these categories. Thus the three missions chosen cover the complete range of expected aircraft environments.

The next choice was to identify specific MDSs within each group for inclusion in the sample. Within the various data systems used, data is collected by and reports are provided by MDS. Thus, the reports which are provided cover all of the avionics in a single MDS. In addition, operations and support is performed by MDS. For these reasons, the number of MDS investigated was limited in order to keep the data collection and analysis within the scope of this effort. In choosing MDS to include in the data base, a number of criteria were used: the aircraft would be of relatively recent vintage, the aircraft would have a large maintenance data base, and the installed avionics on the various aircraft would represent a spread in technology. For Fighters, the F4 is a logical choice, since this aircraft forms a majority of the inventory for this mission. Within the F4 series, two aircraft were chosen, the F4E and the RF4C. The F4E is the prevalent F4 model while the RF4C has a number of reconnaissance systems not found elsewhere. In the Phase II effort additional LRUs were selected from the F-111D primarily because a large number of LRUs not previously considered were installed in this aircraft. Many of these LRUs have digital components representative of the first generation of digital avionics design. To balance older technology of the F4s and F-111D, the F15 was also included in the selections. This aircraft uses newer technologies and sufficient data is available to make its

use statistically meaningful. Bombers chosen were the B52G/H and the FB-111A, with the FB-111A currently having relatively more modern avionics for this mission type. In the area of cargo aircraft, the C130 and C135 series comprise a majority of the fleet. Also, a KC-135A operates very similar to a bomber, allowing for a correlation between these types. The C130E was chosen from the C130 series, as it is the prevalent model. To balance the technologies in the data base, the C5A was used to round out the list.

The next step was to group avionics into various functional areas which affect reliability data. The areas used are communications, navigation, and sensory. The main differences between these groups are in utilization and the power levels at which they operate. Further investigation showed that within the sensory category, electronic countermeasures have distinguishing characteristics, such as low utilization, which could cause this category to be further separated.

The communications group includes items such as radios and IFF equipments. The power outputs of such devices are low when compared to radars and other sensory devices and the utilization of the transmitter portions, a driving functional area for Logistics Support Costs (LSC), is very low, usually one percent of the time or less. Navigation devices include any item used for navigation, such as TACANs, doppler radars, Inertial Navigation Systems (INS), and glide-scope receivers. These items are generally utilized whenever the aircraft is flying, i.e. transmitters are used all of the time, and operate with higher power outputs than the communications devices. The sensory group includes radars, bombing computers, ECM, and various electrical, thermal and other devices for monitoring the environment around the aircraft. Except for ECM, the actual utilization of this equipment is high and the power levels greater than for other categories. Within each category, the criteria used in choosing LRUs was to obtain representative items over a number of technologies and aircraft missions for each of the functional categories. If possible, identical LRUs were chosen across aircraft types, for example an AN/ARC-109 radio in Fighters and Transports and the AN/ARN-67 receiver in Bombers and Transports. In addition, similar units were chosen across technologies in air craft MDS, such as the AN/APQ-120 radar transmitter in the F4E, the AN/APQ130 radar transmitter in the F-111D and the AN/APG-63 radar transmitter in the F-15A.

The next step was to review the data base to determine which candidate LRUs had sufficient data for inclusion. A number of problems, such as modifications to aircraft which changed the avionics, errors in WUC books which showed items being present which were not, and low utilization of an item resulting in a lack of data, produced the requirements to change the data sample. For the Phase I effort, the original data base included

eighty-five LRUs. After changes, additions and deletions this count was reduced to sixty-three LRUs for analysis in Phase II. Seventy-six additional LRUs were originally selected at the beginning of Phase II. Again, through a similar modification process and analysis of data, this count was changed to sixty-five. The combined Phase II data base for regression analysis, therefore, initially consisted of 128 LRU data sets. The number of LRUs in this study is summarized in Table 8.

TABLE 8

SUMMARY OF LRUs INVESTIGATED by MDS

PHASE I

MDS	Number of LRUs In Original Selection	Number of LRUs In Model Data Base
F-4E	17	10
RF-4C	10	8
F-15A	12	10
B-52G/H	29	18
KC-135A	7	6
C-130E	4	5
C-5A	6	6
Total Phase I	85	63

SUMMARY OF LRUs INVESTIGATED by MDS

PHASE II

MDS	In Original Selection	In Model Data Base
F-4E	0	3
F-15A	15	17
F-106A	0	2
F-111A	1	0
F-111D	22	19
B-52H	0	1
FB-111A	19	10
C-130E	6	4
C-5A	13	9
Total Phase II	76	65
Combined Total	161	128

The data available at the end of each Phase was analyzed using the multiple regression analysis techniques of the Linear Least Squares Curve Fitting Program (LLSCFP). This Program provides the analyst with a sophisticated tool, using a large number of statistics, tables and plots, to obtain the "best" fit of the data. The basic approach to this analysis as highlighted in Section V and detailed in Volume II, involved preliminary runs of the Program with most or all of the twenty-one independent variables (design characteristics) defined in Section III. These runs were first made without any data transformations and their logarithmic and other operations on the data were introduced. Successive runs were made in which uninfluential independent variables were removed and the effects of transforms were investigated. Using an iterative technique, the fit of the equations, as defined by the thirty-three statistics, was improved until a satisfactory fit was obtained for the data.

The present configuration of the Avionics Laboratory Predictive Operation and Support (ALPOS) model, Version 2, incorporates PER's developed during both Phase I & II. This includes, as an option, the original relationships to predict Maintenance Manhours per Operating Hour (MMH/OH), Logistic Support Cost per Operating Hour (LSC/OH) (as defined by the IROS data system), Mean-Time-Between-Failures (MTBF), Mean-Time-Between-Maintenance-Actions (MTBMA), Training Costs per Operating hour and NRTS. New, enhanced Parametric Estimating Relationships (PER's) to predict not only the total MMH/OH and LSC/OH; but elements of these parameters, such as unscheduled MMH/OH or field LSC/OH, are included. Also, optional PERs using NRTS as an independent variable and a PER to predict the cost of a depot repair have been developed. These options are a preliminary step towards a technique for assessing the impact of alternative maintenance philosophies. Separate algorithms are used in the model to calculate spares and support equipment costs. The spares cost algorithms are based on the Air Force inventory control procedures of AFLCP 57-13, Recoverable Inventory Control Using Mod-Metric. The support equipment cost algorithms are based on prior studies.

This approach provides, as the validation investigation would indicate, a credible model for estimating the impact of design alternatives on elements and drivers of O & S costs with limited data inputs. ALPOS can be a valuable analytical tool for use in studies of avionic designs and logistic tradeoffs during the early conceptual phase.

SECTION III

DATA COLLECTION

The first step in each phase of the development of the ALPOS model was to identify available data sources, the format and extent of the data contained in each source, and the validity and ease of use of each source. A large number of potential sources, both in Government and contractor control, had been identified prior to commencement of the data collection. Those sources which did not appear suitable for developing the model's data base after a review of the associated documentation, are not included in this discussion. In the second phase effort the possibility of utilizing a new improved logistics support cost data system was explored. Unfortunately, plans for automating this system were still being formulated at the start of this investigation and, consequently, data covering the broad spectrum of avionics LRUs was not available from this source. Because this system offers great potential for use in any update of the data base, it is commented upon in greater detail in Section VIII, Feasibility of Further Model Enhancements.

The first data source identified was the existing Air Force Data Systems which contain cost and maintenance information to include data in the Maintenance Data Collection (MDC) System of AFM 66-1, Increase Reliability of Operational Systems (IROS) and Visibility and Management of Operations and Support Costs (VAMOSC). These sources were especially useful since they contain data from a large number of sites over a relatively long time period (one year's worth of data was used in constructing this model) and they reflect field conditions and not a theoretical or controlled environment. An advantage of AFM 66-1 and IROS data products is that they are organized by Work Unit Code (WUC). This allows costs to be segregated by aircraft Mission-Design-Series (MDS) to a specific area. It also allows the analyst to make a credible estimate of actual operating times. There are a number of areas which must be approached with caution when using these data systems. The information contained in the various systems reflects exactly what is input from the field, including mistakes in recording items such as National Stock Numbers (NSN) versus WUC. Therefore, the data system user must screen the data products to compare the outputs of each. In each data system, costs are derived from maintenance factors, such as maintenance manhours per operating hour and standard cost factors obtained from various Air Force manuals. The analyst must understand the methods used to derive these costs to compare systems. In addition, the various cost factors used have to be analyzed to determine their currentness. The identification and analysis of these potential problem areas allows the analyst to use the data from the various data systems with a high degree of confidence in the results.

The second data source identified was site visits and contracts with various Air Force agencies. These visits included trips to Air Force Logistics Command Headquarters, a number of Air Logistics Centers and operating sites for each aircraft MDS. The visit to AFLC provided a working knowledge of the various data products available in the Maintenance Data Collection (MDC) System of AFM 66-1. Information was also gathered on the Increase Reliability of Operational Systems (IROS) Program. The visits to the Air Logistics Centers provided contacts with personnel in systems and item management. It was not possible to directly obtain data on depot repair activities from site visits. Consequently, the IROS data system was utilized as a source of depot repair cost data. The visits to the operating sites were made to obtain field data and to interview field maintenance personnel regarding the appropriateness of the candidate LRUs. Since there is no central library of Technical Orders (T.O.'s) for avionics LRUs, a major activity during these visits was the extraction of leading particular information from Field Maintenance Manuals and component counts from Illustrated Part Breakdowns (IPB's). The format of the data collection sheet used for this effort is displayed as Figure 2.

The other sources of data utilized were various Westinghouse activities, published reports, and engineering analyses. The Westinghouse sources included engineers associated with LRUs either designed by Westinghouse or interfaced with Westinghouse systems, logistics and other specialized experts, raw data obtained from the Air Force and field service personnel, and various technical publications available in our library. This source was utilized to the maximum extent possible, in order to minimize the cost and effort required for data collection. The literature review covered acquisition cost estimating for electronics, the use of CERs to estimate support costs, evaluations of various data systems, and Life Cycle Costing. The purpose of the review was to identify the results from previous investigations which could be incorporated in this model. The engineering analyses were performed by various personnel assisting in development of the model.

PREDICTIVE OPERATIONS AND MAINTENANCE COST MODEL

LINE REPLACEABLE UNIT (LRU) DATA COLLECTION

Sheet 1 of ____

MDS ________ WUC ____________ A/N ________

TYPE ________

NOMENCLATURE ____________

MANUFACTURER ____________

LEADING PARTICULARS:

WEIGHT = ________ LBS. FROM T.O. ________

LENGTH = ________ INCHES DATE ________

WIDTH = ________ INCHES CHANGE ________

HEIGHT = ________ INCHES # PAGES ________

VOLUME = ________ CU. IN. POWER DISSIPATION:

POWER REQUIREMENTS:

INPUT ________ PER TECH ORDER DERIVED

____

OUTPUT ________

____

OTHER DESCRIPTIVE INFORMATION (e.g., function in avionics subsystem, use of digital/analog circuitry, degree of BIT)

EQUIPMENT SPECIALIST/TECHNICIAN: NAME ________

LOCATION ________

PHONE NO. ________

Figure 2. Data Collection Sheet Format

Air Force Data Systems
Maintenance Data Collection System (MDCS)

The Air Force has an enormous data collection and analysis effort to collect, classify, and evaluate maintenance data. The key to this effort in the field is the MDCS, per AFM 66-1. Data from this system is used to generate a large number of reports. Four of these reports were specifically investigated in this study:

a) Summarized Maintenance Actions for selected Work Unit Codes. Report Control Symbol (RCS): LOG-MMO(AR)7179 (formerly RCS: 5-LOG-K261). This report contains detailed failure data on each MDS to the fourth level of the WUC. The fourth level of the WUC is a five-digit number (digits one and two are one level) which describe a specific work area in the hardware. The level of breakdown, i.e., what is an LRU, differs from MDS to MDS, although for newer MDS it is usually the third level, with the fourth level being an SRU. Part of the analysis effort was to identify the level of an LRU, for each MDS. This report provides much of the details of the information summarized by the reports discussed below. The "5-Log" report was used to investigate detailed maintenance actions for some of LRUs in the data base as well as one means for determining the percentage of failures detected by automatic test for "on" equipment LRU maintenance actions. This report was obtained on both microfiche and hardcopy printouts. The microfiche version is automatically generated whenever an LRU MTBF computation falls below a specified Action Limit. For other LRUs, the hardcopy version was obtained by special request with a turn around time of only a few weeks.

b) Maintenance Actions, manhours, and aborts by Work Unit Code, RCS: LOG-MMO(AR)7170 (formerly 6-LOG-K261). This report summarizes on microfiche, monthly and semi-annually, the key maintenance parameters, by WUC to the fourth indentured level, as described previously. Factors included in this report are the average monthly inventory, utilization, failure data (number of occurrences, for both failure and other malfunctions, and mean time between failures and maintenance actions), scheduled, unscheduled and shop maintenance manhours and the number of units repaired at shop, condemned, and NRTS. These maintenance parameters were used in the Regression Analysis to formulate the model. Thus, the maintenance parameters obtained from the ALPOS model should approximate the data in this report, as demonstrated in the validation effort.

c) Maintenance Manhour per Flying Hour by Weapon, Command and System, RCS: LOG-MMO(AR)7185 (formerly 25-LOG-K261). This report summarizes maintenance manhour data to the system level, i.e., the first indenture level of the WUC. Due to the level of summary, it was useful only as a general check of the other reports.

d) Maintainability Reliability Summary, RCS: LOG-MMO(AR)7220. This report contains maintenance data including the failure occurrences, manhours expended per repair, distributions of failure symptoms and corrective actions taken, and MMH/OH. The data was provided to the fourth indenture level of the WUC for specific second indenture level WUCs. This data is a second source for data contained in LOG-MMO(AR)7170 and a source of the percentage of failures detected by automatic test. Due to changes in the selection of LRUs for the data base and the relatively long processing cycle, only a partial set of these reports were obtained.

INCREASE RELIABILITY OF OPERATIONAL SYSTEM (IROS)

A primary source of logistics support costs was the IROS program, or what is now technically referred to as the Logistic Support Cost (LSC) Ranking Data System (K051). This system includes a series of programs designed to compute the LSC of all Work Unit Codes (WUCs) within a particular mission design and series (MDS). It is applied to all major MDS where the WUC structure and related maintenance actions required for operational support can be identified. It should be noted that the cost value computed for individual WUCs is necessarily limited, because all logistics support cost of a weapon/support system cannot be allocated to specific WUCs (11). IROS utilizes data from the MDC system of AFM 66-1, AF 65-110 On Equipment Status Reporting and Depot Level Repair Management Systems. The primary elements considered in computing LSCs are base maintenance manhour costs; Technological Repair Center (TRC) repair and overhaul costs; cost of packing and shipping TRC reparables; and replacement costs of base and TRC condemnations and expendables (12). This system, therefore, can be used to represent much of the annual recurring LSC at the WUC level. A number of data products were utilized from IROS, including:

a) Logistics Support Cost Ranking - Work Unit Code Status K051.PN3L (RCS: LOG-MMO(Q)7213). This report gives total LSC for the current quarter and the previous three quarters. It was used to calculate the annual LSC and to apportion the elements of LSC. Due to wide variances in LSC from quarter to quarter, caused by changes in funding and operational requirements, LSC must be calculated by summing four quarters of data. Since only total LSC is shown, this is the only cost which is presented on an annual basis.

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(11) Logistics Support Cost Ranking (Draft) AFLCM 66-18, Chapter 17, No date.

(12) LSC Ranking (Draft) op. cit.

b) Logistics Support Cost (LSC) Breakdown - Current Quarter Computation K051.PN4L (RCS: LOG-MMO(Q)7213). This report contains a breakdown of the quarter's costs for field maintenance (labor and material), specialized repair activity maintenance (labor and material), packing and shipping costs, and condemnation replacement costs. This report was used to obtain the relative values of these costs. These costs were apportioned, using the ratio of the quarter's costs to annual costs, to obtain annual values.

c) Logistics Support Cost Ranking - National Stock Number (NSN) K051.PN6L (RCS: LOG-MMO(Q)7215) - This report shows monthly LSC by NSN and the percentage contribution to the total monthly MDS LSC. It was used to relate NSNs to Work Unit Codes and to identify which NSN physical characteristics to use for each WUC. Its main use was in the analysis of the validity of NSNs.

d) Logistics Support Costs File Maintenance Register K051.PN8L (RCS: LOG-MMO(Q)7213) - This report contains logistics related information such as unit price and packed weight. It was used to identify NSNs to be used in the data base from the K051.PN6L report and as an alternative source of logistics data.

COST AND PERFORMANCE RANKING

Another report reviewed at the initiation of this effort was COSPERANK generated by Oklahoma City Air Logistics Center (Office Symbol: MMEAR), which contains support cost and failure data for high support cost systems. This report contains data by NSN and is not broken down to the MDS level. It was used to obtain MTBMAs, as an alternative source for cost, and as a check for support costs. Although the data in COSPERANK appears to be valid, a number of characteristics prevented its use in constructing the model. Since only high LSC items are included, it would not be possible to avoid biasing the regression coefficients against low LSC items. Also, it is impossible to reconcile the differences in NSN and WUC because each NSN may be used in a large number of different aircraft and each WUC may include many NSNs, of which some are invalid. Thus any data obtained from this report was subordinate to the other data systems.

Visibility and Management of Operating & Support Costs (VAMOSC)

Operations and Support Costs Evaluation Reports (OSCER) generated as a part of VAMOSC program by the Comptroller of the Air Force were also reviewed. These reports include all operating and support costs by MDS, with costs broken down to various

accounting categories. This reporting system was developed by the Air Force to partially satisfy DoD Management by Objective 9-2 to "implement a cost-effective system to identify maintenance and operation costs by weapon system (13)". Numerous cost allocation techniques and assumptions are used in this system to link many diverse Air Force data bases that comprise elements of O&S costs with non-cost data such as aircraft status and utilization reports. The preface of the draft OSCER Users Manual carefully points out the risk associated with this attempt to make O&S costs visible at the MDS level. One element of O&S cost shown on this report is training costs. It was not possible to obtain specific training costs for all of the avionics LRUs in the data base from other data systems and, therefore, OSCER was used as the primary source of training costs. Consequently, it was necessary to derive training costs at the WUC level by apportioning the total non-flying OSCER training costs for a system in the same ratio as the LSC at the WUC level to the total system LSC.

The OSCER User's Manual (Draft) describes the following Chart of Account Codes (CAC) that comprise the total training cost:

CAC 4211.00	ACQUISITION AND TRAINING, OFFICERS, NOT ON FLYING STATUS - FIXED
CAC 4221.00	ACQUISITION AND TRAINING, ENLISTED, NOT ON FLYING STATUS - FIXED
CAC 4212.00	ACQUISITION AND TRAINING, OFFICERS, NOT ON FLYING STATUS - VARIABLE
CAC 4222.00	ACQUISITION AND TRAINING, ENLISTED, NOT ON FLYING STATUS - VARIABLE

The Manual also provides the following description of the factors which are included in deriving the training costs:

> "This element estimates the annualized cost to the Air Force of bringing a unit's strength, direct and indirect, from civilian life to their first duty station. The costs are a composite of the average cost of recruiting, accession travel (one way cost to an initial training base or civilian

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(13) OSCER Users Manual (Draft), Directorate of Management Analysis, HQ USAF, no date.

institution), TDY, initial clothing, education/training and miscellaneous allowances. These are considered fixed costs. Additional training is required before an Air Force Specialty Classification (AFSC) is attained. The OSCER system treats the latter as the variable portion of the cost of acquisition and training."

The algorithm used in OSCER for the four training cost categories draw on a number of data sources/systems including:

1.) Acquisition cost factors from HQ USAF (ACMCA)

2.) Nonrated AFSC cost factors from HQ ATC (ACM)

3.) Officer retention rate from the Officer Loss Rate Development System

4.) Airman retention rate from the Airman Loss Probability System

5.) Allocated assigned military strength from RCSHAF-ACM (A)7501, OSCER System

The OSCER must also make a number of assumptions for allocating various costs. In the case of training data the following assumption is made:

> "Military Personnel Center assigned strength data is functionally but not MDS-identified, even when appropriate. That is, we may determine from the MPC functional activity code (FAC) of assignment what a man does and in what functional area he does it (for example, he may be a landing gear repairman working in the field maintenance shop), but we may not directly relate the man's expenditure of time to any aircraft, at least without some intervening allocation procedure.
>
> The OSCER system contains an allocation procedure which, for the present, is assumed valid for use in estimating unit acquisition and training costs."

Another important assumption is:

> "It is recognized that enlisted personnel are upgraded within a given AFSC, are cross-trained into another AFSC, etc., but in OSCER costing methodology, it has been assumed that the grade level remains unchanged at the 3-level."

The User's Manual presents the following algorithm used in the cost allocation:

A. CAC 4211.00

$$\text{(Officer, Acquisition/ Training, Fixed}\dots_r = \sum \left[(\text{Fly Ops} + \text{WS Maint} + \text{BOS Str})_{ijkqr} \times (\text{Retention Factor})_r \times (\text{Acq/Tng Fixed Cost Factor})_r \right]_{ijkqr}$$

B. CAC 4221.00

(Enl, Acq/Tng, Fixed) = Same as A, above using enlisted data.

C. CAC 4212.00

$$\text{(Officer, Acquisition/ Training, Variable}\dots_r = \sum \left[(\text{Fly Ops} + \text{WS Maint} + \text{BOS Str})_{ijkqr} \times (\text{Retention Factor})_r \times (\text{Acq/Tng Variable Cost Factor})_r \right]_{ijkqr}$$

D. CAC 4222.00

(Enl, Acq/Tng, Variable) = Same as C, above using enlisted data

where, r = All non-flying status AFSCs identified with unit.

NOTE: Training costs associated with military personnel not on flying status are allocated on the basis of the AFSC distribution of assigned non-aircrew military personnel identified to the flying unit and probabilistic retention factors associated with each of the AFSCs.

The variable costs represented by CAC 4212 and CAC 4222 reflect the Technical School Training at Air Training Command's (ATCs) Technical Training Centers. The fixed cost derived by CAC 4211 reflects Officer Acquisition through USAFA, ROTC, OTS, etc. and CAC 4221 reflects enlisted basic training at Lackland AFB.

In the Phase I effort, the total of all four of the training costs per MDS were used as a baseline for allocating costs to the various LRUs in the data base for that MDS. The OSCER reports for all MDS in the data base, including the F-111D and FB-111A which were received for the Phase II effort, were generated in a different format from the original reports. The revised format conforms with the guidelines of the Cost Analysis Improvement Group (CAIG). From conversations with personnel in the Directorate of Management Analysis Analyses, HQ USAF, Life Cycle Costing Organization (ACMC), it was determined that the costs represented by CAC 4211 and CAC 4221 no longer appear on the OSCER report. The new format shows advanced training under the category Major Force Program (MFP) 8 and the costs are essentially the same as those shown on the original OSCER under CAC 4212 (for Officers) and CAC 4222 (for enlisted men).

Therefore, it was not possible to obtain F-111D and FB-111A total training costs for Phase II similar to those used in Phase I. In order to obtain the same category of training costs for all aircraft in the combined Phase II data base it was decided to extract the CAC 4222 type costs from the revised reports and reallocate costs to all LRUs now in the data base. These costs, rather than the total costs, should more accurately reflect the costs of advanced training for technicians and, consequently, this may be viewed as a refinement of the methodology used for deriving training costs from OSCER for use in developing the Phase II training cost relationship.

For the Phase II effort, an alternative source of training cost information was investigated. This involved obtaining total training cost data by course number per HAF-ACM(AR)7108, Average Training Cost Per Graduate. Table 9 shows the cost elements which are considered in the total costs extracted from this report. Before this data was obtained it was first necessary to request an LRU-WUC to course number cross-reference from the Air Training Command. For many of the LRUs (over 70) it was not possible to obtain such a cross-reference which necessitated that OSCER be used as the primary source of cost data. In other cases where a cross-reference could be obtained, a review of the data indicated that training for maintenance of LRUs in more than one MDS was conducted under the same course number, further complicating analysis. For example, the ATC course for the Avionics Communication Specialist, E3ABR-32830-000, included training for those technicians maintaining LRUs on the F-15A, B-52H, KC-135A, C-5A and C-130E. Without additional information concerning the relative participation of technicians for those MDS, it was not possible to attempt an allocation of cost for such courses to even the MDS level. Other courses cross-referenced to one particular MDS were for avionic subsystems that were more diverse than anticipated. A case in point is the ATC course for the F-15A Integrated Avionics Component Specialist F, G3ABR-32631-F003, which encompassed training for subsystem WUCs: 52A, 65B, 71A, 71C, 74A, 74F, 74J and 74K. Consequently, this would require apportioning the cost

TABLE 9

APPLICABLE COST ELEMENTS -
AVERAGE TRAINING COST PER GRADUATE
(HAF-ACM(AR)7108)

A. Direct Costs

1. Officer Staff Pay
2. Enlisted Staff Pay
3. Civilian Staff Pay
4. Nonpersonnel Costs

B. Indirect Costs

1. Officer Staff Pay
2. Enlisted Staff Pay
3. Civilian Staff Pay
4. Nonpersonnel Costs

C. Student Costs

1. Pay and Allowances
2. TDY Travel
3. TDY Per Diem
4. PCS Costs

D. Command Support

1. Officer Staff Pay
2. Enlisted Staff Pay
3. Civilian Staff Pay
4. Nonpersonnel Costs

data not only to LRUs within a subsystem but to different subsystems. Because of these problems, it was concluded that there was no clear advantage or benefit in using the report for developing the training cost data base when compared to using the OSCER training data.

Data Collection Methodology

The first step in the data collection was to identify the source of each report and to request copies. The AFM 66-1 and IROS reports were obtained from Headquarters, AFLC (Office Symbol: LOLMA). Requests were submitted through the Project Monitors and a number of reports were received covering the listed data products. The COSPERANK reports evaluated in Phase I were obtained from Oklahoma City and OSCER reports from the Air Force Comptroller's Office (Office Symbol: AFACM). Due to voids in some of the data products received, additional requests for data were required on some of the AFM 66-1 reports, especially the LOG-MMO(AR)7220 or "27-LOG" reports.

The next step was to analyze the data systems. This analysis looked at the contents and completeness of each data system and the validity of the data in each. Data to an LRU level is contained in the AFM 66-1, IROS and COSPERANK reports. COSPERANK since it is structured to identify high support cost items, does not include the middle and low support cost items. Elimination of those items not in COSPERANK from the data base would bias the results towards the "high burners" and cause the model to give erroneous results. Both IROS and AFM 66-1 reports cover a wide range of costs and were therefore used in the construction of the data base. It should be noted that items which do not experience a failure in a particular quarter or half year will not show up in these reports. Thus very reliable items, such as simple motors, may have no current entries. In addition, low utilization Electronic Counter Measures (ECM) items, which have an average utilization factor of .3, are often excluded from the data reports. Inclusion of such items often necessitated that the next higher assembly, which is usually an aggregate of low failure items, be used, even though it may not be an LRU. Another problem which surfaced is that much of the data in these reports is coded as being incomplete. A review of these items, which are coded with a "P", shows that the parameter values do not vary significantly from those for complete items; and therefore, it is assumed that the incompleteness does not affect the accuracy. This assumption is based on the theory that the incompleteness covers all data elements, including utilization, i.e. the data sample does not cover all use of an item. The results obtained from interviews with various Air Force personnel substantiate this theory. An advantage of AFM 66-1 data is that it is developed from a consistent methodology based on AFTO Form 349 input data. This form is filled out by maintenance personnel for each maintenance action. Thus, these forms represent a large

sample of field maintenance actions. Since one form is filled out for each action, and each action consumes resources which must be reported, the number of actions recorded is very close to the actual number performed in the field. The manhours recorded often reflect standards rather than actual hours consumed, especially at depot, but the reports show the actual number of hours charged to perform a task. Experience and the interviews show that most often the time charged to complete a job, and hence cost, is a function of the labor standard rather than actual time expended. This practice is common in the maintenance area, both commercial and Government, and is accepted as a valid procedure. Indeed, measurement of actual task times in the field would provide a biased sample, depending on the proficiency of the technician and the failure mode encountered when used to calculate realized costs. Of course, as with other systems, a technician's "dead time", i.e. the period when he is involved in other duties or not utilized due to a lack of work, is not included implicitly in the analysis. But, most often this time is buried in the standard and thus best approximated using the standard. Based on conversations with maintenance technicians at each site visited in the site survey, it appears that information is entered into the systems consistently, and, to a certain extent, accurately. At a number of bases, the internal quality control procedures for monitoring the accuracy of information recorded on AFTO 349 forms was impressive and appeared to be effective. This was especially true of the procedures at Cannon AFB for F111D Avionics LRU Maintenance. This included two levels of review of forms accuracy as well as the feedback of corrective action to technicians and the monitoring of LRU maintenance histories. A basic part of this procedure involved the review of AFTO 349 error rates detected by computerized matching of WUCs and part numbers. It is cautioned that this survey covered a limited number of bases, less than ten percent of all CONUS flying bases, and that the emphasis placed on preparation of the forms varies greatly among bases depending on command emphasis.

There are a number of disadvantages to using this data system. The most obvious is that the data system was not conceived or designed to serve as a cost collection system. The purpose of the system, as stated in AFM 66-1, is "an aid to the management of maintenance resources". It is intended to provide base level and major command Headquarters with information for material management. Therefore, it is concerned with the resources expended to complete maintenance task and not the total resources, and their cost, required to support a system, sub-system, or LRU. Items such as non-recurring investments for spares and support equipment, and indirect costs for training and support of support equipment are not included in these costs. It should be noted that resources in excess of normal requirements are needed to meet surge and war time requirements. Due to the nature of the maintenance data, which appears to by cyclic with one year cycles, the use of six months or one quarters data to

calculate costs can lead to errors. The data collected from both AFM 66-1 and IROS was for a one year time period, i.e. one cycle. One year cycles can be explained since they result from changes in weather conditions, utilization due to fiscal year budget constraints and annual tests. The use of data for this period appears to be sufficient to calculate bias. A vast amount of data is input into the system, about 5,000,000 transactions per month, so that errors are inevitable. These errors result from a number of sources such as entering an invalid WUC, keypunch errors, use of the wrong WUC, etc. In analyzing the data systems, the basic data in each was compared to obtain a correlation of parameter values. In addition, since IROS records costs by both WUC and NSN, an estimate was made of the completeness of data. It appears that the charges of incompleteness of this data can most often be traced to input errors or misuse of WUCs. It should be noted, however, that a recent "academic" investigation into the accuracy of AFM 66-1 data concluded that the data was, in general, accurate and capable of providing an effective basis for logistics decision making. (14)

The IROS reports give a calculated support cost. This cost is calculated from the maintenance factors and standard cost factors. The breakdown of cost against WUC and NSN allows for an analysis of the validity of costs. The "PN8L" File Maintenance Register report contains a listing of NSNs associated with each WUC. A preliminary review of the NSNs and noun nomenclatures for each WUC showed that a significant number of NSNs were in error. Since the "PN8L" report is also a source of unit price and standard depot repair cost information associated with an NSN to WUC mapping, a great amount of effort was devoted to satisfactorily resolving these discrepancies. The PN8L discrepancies appear to be of four types: error in the NSN, higher or lower level WUC assigned to an NSN, wrong WUC assigned to an NSN and an unidentified WUC. The first type of error occurs when one or more digits of an NSN are in error. Since there is no check of NSN to WUC, the invalid NSN is entered into the data base. The result is that the costs are credited to the wrong hardware item or to a non-existent item. This error is easily identified since only one maintenance action will appear against the NSN and, usually, the entry is next to a similar, valid NSN. A review of noun nomenclature was also used to identify these errors. Thus, each WUC was reviewed manually to screen out false NSNs. The second error occurs when a component, such as a printed circuit board, or a higher assembly, such as a receiver, is entered into the system. For example, a WUC of 74FAO may have an item whose NSN nomenclature actually places it in the 74FAC WUC. Conversely, the 74FAC WUC may be assigned to an item with a 74FAO WUC. This error can be identified by: a

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(14) How Good Are Maintenance Data?, J.F. Stanhagen, Jr., Logistics Spectrum, Spring 1978

review of the noun-nomenclature to make sure it matches that of the WUC; a review of primary NSNs provided by item managers; and looking at the apportioned percentage of WUC LSC for the NSN. For most WUCs, a majority of the LSC is apportioned to a few valid NSNs. But a number of invalid items, each with a small apportionment, will appear in the data. This backs-up the finding that a majority of the data is valid, with errors slipping in for a few items. This problem was approached by NSN, a minimum percentage being used as the basis for screening out superfluous entries in PN8L. The identification of a wrong WUC assignment, typically assigning an IFF WUC of 65AAO to a radio with a 63AAO WUC, was done by reviewing the National Stock Class (NSC) of each NSN to assure that it belonged in the assigned WUC area. In addition, a review of noun-nomenclature, especially type designations, and cost apportionments was used in the analysis. The final problem, unidentified WUCs, has the opposite effect of those previously listed, in that items which should be included in the data base are not. Again a review of NSNs assigned to unidentified WUCs was performed, using the related procedures, and errors identified. It appears, for the WUCs investigated, that the errors in costs and maintenance factors caused by these input errors cancel and the outputs are close to the corrected values. There was some concern expressed elsewhere that IROS does not give adequate cost visibility, especially at the Depot level. A Rand Report, R-1569-PR, entitled "An Appraisal of Logistics Support Cost Used in the Air Force IROS Program", indicates that "only about 53 percent of the total relevant base-level costs for unscheduled maintenance and less than seven percent of the total relevant Depot-level costs for the A-7D are actually being gathered" by the KO51 data system for IROS. In an attempt to gain another perspective on the adequacy of IROS, some aspects of this report were discussed with a member of the controlling organization. Apparently, as a result of the subject report, much analysis was done on the applicability of the findings to other aircraft. It was concluded that base and Depot costs, as gathered through the KO51 data system, are given adequate visibility, especially for the aircraft considered in the data base for the predictive model. Although a number of improvements could be made to IROS, it is nevertheless, the only logistics support cost data system currently operational which is WUC oriented and attempts to account for Depot-level maintenance which is NSN oriented. It should be noted, however, that the work now being performed by the AFLC to improve LRU/SRU support cost visibility, as described in Section VIII, involves an enhancement of the IROS KO51 data system and that the above mentioned report did influence the study of required improvements.

Field Trips

A major part of the data collection efforts in both phases of study involved visits to the Pentagon, AFLC Headquarters, ATC Headquarters, four Air Logistic Centers (ALCs) and nine Air Force Bases with operational units. The field visits made in Phase I and II are summarized in tables 10 and 11, respectively.

Initial visits to the Pentagon, AFLC Headquarters and the Ogden, Oklahoma and Warner-Robins ALCs were made during Phase I to survey various data systems as well as to formulate a list of LRU candidates. Through "lessons learned" and the establishment of contacts with personnel at these sites, it was possible to expedite the collection of much of the data for the Phase II effort. The preliminary list of Phase II LRU candidates was partially compiled by means of telephone interviews with technicians and supervisors at the ALCs and bases previously visited. This approach was essential in identifying candidate LRUs having digital components which were not selected in the Phase I data collection. It was necessary in both phases, however, to conduct in-depth interviews with ALC personnel to verify the appropriateness of the LRUs originally selected and to identify alternatives when required.

TABLE 10

SUMMARY OF FIELD TRIPS, PHASE I

Organization Visited	Dates Visited	Personnel Contacted	Purpose of Visit	Remarks
A. Pentagon Wash., D.C.	29 June 1977	Mr. Al Frager, OASD	Discuss VAMOSC and OSCR System.	Referred to Ms Swinson.
		Ms Vivian Swinson, Air Force Comptroller Office (AFCM)	Obtain OSCR description and reports.	Request made for OSCR reports subsequently to Ms Swinson.
B. Wright-Patterson AFB, OH	21-22 June 1977	Lt. Tom James, AFAL	Kick-off of model development.	Obtained information on COSPERANK and "6-LOG" reports.
		Ms Eleanor Puckett, AFLC	Discuss and obtain AFM 66-1 and IROS data products.	Request subsequently made for data products.
		Mr. J. White, PRAM Office	Discuss Cost Performance Analysis Reports.	Contact OCALC.

TABLE 10 (Continued)

SUMMARY OF FIELD TRIPS, PHASE I

Organization Visited	Dates Visited	Personnel Contacted	Purpose of Visit	Remarks
C. Oklahoma City ALC, OK Ogden ALC, UT	18-22 July 1977	Ms Margaret Robinson	Discuss COSPERANK data product and D041 data product.	Ordered COSPERANK through AFAL.
		B52 and C135 Systems Managers for Avionics at Oklahoma City.	Discuss peculiar support problems for these aircraft.	Identified several potential problem areas-changed LRU candidate list.
		F4 Systems Manager for Avionics at Ogden.	Discuss peculiar support problems for this aircraft.	As B52/C135 Systems Manager visit.
		Mr. Harold Haddock, Ogden	Discuss SCRAP Model.	Not suited for use in ALPOS model.
		F-16 Acquisition Division	Discuss concepts for support of the F-16.	Established a baseline for new systems.

TABLE 10 (Continued)

SUMMARY OF FIELD TRIPS, PHASE I

Organization Visited	Dates Visited	Personnel Contacted	Purpose of Visit	Remarks
D. Warner-Robins ALC, GA	1-3 August 1977	Item managers for all avionics supported at WRALC (MMIRC and MMIRB)	To discuss maintenance of items and gather data.	Changes to LRU candidate list/limited data available.
E. Langley AFB, VA	16 August 1977	Cpt. Jim Cox, TAC Headquarters	To discuss user problems and arrange visits to TAC bases.	Identified F-15/F-4 problem areas and support system problems-arranged trips.
F. Luke AFB, AZ	19, 22-23 August 1977	AMS	To review maintenance procedures on F-15 avionics.	Gathered field failure data from shop records/identified additional problem areas.
G. ARINC Research Co., Annapolis, MD/Andrews AFB, MD	28 September 1977	ARINC Research Co.	Review Navigation Equipment Handbooks prepared by ARINC.	Weight and volume data obtained on navigation equipments.

TABLE 10 (Continued)

SUMMARY OF FIELD TRIPS, PHASE I

Organization Visited	Dates Visited	Personnel Contacted	Purpose of Visit	Remarks
		459th FMS, Andrews (AF Reserve)	Discuss maintenance and review C-130E TOs.	Reviewed -2 and -4 TOs on C-130E avionics.
H. Dover AFB, DE	3-4 October 1977	436th AMS	Discuss maintenance of C-5A and review TOs.	Reviewed -2 and -4 TOs, discussed maintenance problems.
I. Seymour Johnson AFB, NC/Shaw AFB, SC	17-19 October 1977	4th CRS, Seymour-Johnson AFB 363rd CRS Shaw AFB.	Discuss maintenance of F4E (4th CRS) and RF4C (363rd CRS) and review TOs.	As at Dover AFB.
J. Langley AFB, VA	27-28 October 1977	1st CRS	Discuss maintenance of F15 and review TOs.	As at Dover AFB.
K. Grand Forks AFB, ND	26-28 October 1977	319th AMS	Discuss maintenance of B52H and KC135A and review TOs.	As at Dover AFB.

TABLE 11

SUMMARY OF FIELD TRIPS, PHASE II

Organization Visited	Dates Visited	Personnel Contacted	Purpose of Visit	Remarks
A. Wright-Patterson AFB, OH	2-4 August 1978	Lt. Tom James & Daniel Ferens/ AFAL/AAA-3	Kick-off of Phase II model development	Scanned "6-LOG" and IROS microfiche for candidate LRU data.
		Major Douglas Palomaki/ AFLC/LOLR	Investigate IROS enhancement effort.	Referred to Major Herzog, Air Staff for copy of report.
		Glen Tinsley AFLC/LOLMA	Submitted data request and investigated sources of BIT effectiveness data.	How malfunction code for BIT false alarms to be implemented.
B. Warner-Robins ALC, GA	15-18 August 1978	Item managers/ technicians in MMIRB and MMIRC for all candidate avionics supported at WRALC	Review LRU candidate list, investigate utilization factors, review TOs.	Added/deleted LRUs, obtained names of contacts at other bases, suppliers.

TABLE 11 (Continued)

SUMMARY OF FIELD TRIPS, PHASE II

Organization Visited	Dates Visited	Personnel Contacted	Purpose of Visit	Remarks
C. Dover AFB, DE	30-31 August 1978	436th AMS	Review LRU candidates from C-5A. Extract data from TOs.	Deleted 6 LRUs shown in WUC books but removed from aircraft. Reviewed MADAR inputs to 66-1 MDCS.
D. Sacramento ALC, CA	11-13 September 1978	System Managers/ technicians in MMIR	Review LRU candidates from F-111 A, E and D and FB-111A.	Added/deleted LRUs.
		Engineers in MMEAM	Review draft IROS User's Manual.	IROS uses std. rate/hr for base labor, mat'l and O/H.
E. Cannon AFB, NM	14-15 September 1978	27th CRS	Review LRU candidates from F-111D, Extract data from TOs. Review AFTO 349 inputs.	Extensive on-site contractor maintenance support.

TABLE 11 (Continued)

SUMMARY OF FIELD TRIPS, PHASE II

Organization Visited	Dates Visited	Personnel Contacted	Purpose of Visit	Remarks
F. Pentagon, Wash. DC	19 October 1978	Capt. Corwin/ACMS Major Dale/MMPTS	Reviewed availability of training cost data by course number.	Referred to ATC to obtain LRU to ATC course number cross-reference.
G. Randolph AFB, TX	25 October 1978	Captain Selig/TTQG	Investigate feasibility of obtaining LRU to course number cross reference and submit request.	May not be possible to compile cross-reference for LRUs. Request will be forwarded to Lowery AFB and Kessler AFB.
H. Langley AFB, VA	25-26 October 1978	1st CRS	Review LRU candidates from F-15A. Review "Fail auto test" how Mal code.	Problems with ATE malfunctions necessitated use of LRU shop test standards.
I. Pentagon, Wash. D.C.	1 February	Capt. Roundval/ACMS	Obtained training course cost data per HAF-ACM (AR) 7108.	

In a number of instances it became apparent that some changes to the LRU selections would be required. The reasons for these changes could be briefly summarized as: used on an aircraft but not on bases visited; deployed outside CONUS; insufficient data available from AFM 66-1; LRU was 100% NRTS; and unit was actually an SRU. These changes are reflected in the lists of Tables 1 thru 7. The specific reason for each change will not be elaborated upon in this section but has been referenced in the monthly status reports for this effort. The LRUs shown as being "in model data base" on these Tables are those LRUs finally selected for which a complete set of the major independent and dependent variable data could be assembled. The data associated with each of these LRUs is displayed as Appendix C and represents the data base used at the beginning of the regression analysis for each dependent variable.

While at each of the Air Force bases visited, much of the time was devoted to reviewing the T.O.s, extracting the desired data, if found, and inquiring about the validity of inputs to MDC 66-1 for each LRU. Shop personnel at all bases were most cooperative in assisting us in locating the appropriate T.O.s. Depending upon the complexity of the LRU, data extraction would require anywhere from a half-hour to two or three hours per LRU. The procedures followed in developing each element of the data base are described in Section IV. For the LRUs shown in Table 1 through 8 we did not discover any systematic difficulties with AFM 66-1 inputs which could have impacted the accuracy of results summarized in the "6-LOG".

During the visit in Phase I to Luke AFB, detailed data was obtained to review historical MTBFs for the LRUs in the data base from the F-15A. At that time F-15As were being deployed in increasingly greater numbers during the time period covered by the "6-LOG" data and it was desirable not to rely solely on this source, but to obtain an alternate estimate of MTBF. A review of the MTBFs showed that the AFM 66-1 products contained MTBF data with reasonable accuracy. Indeed, the differences in operational environments for various F-15 units precluded the sole use of data from any one base. As a result of this analysis, collection of peculiar base data was not further pursued because of its redundancy with AFM 66-1 MDCS data for MTBF and MMH. It should be noted that a comparison of the F-15A flying hours from the twelve months of data used in Phase I and the twelve months of data used in Phase II revealed an increase of 132%. It was decided, therefore, to update the Phase I F-15A LRU data with those values of MTBMA MMH/OH, LSC/OH, etc., from the Phase II data which reflected a greatly increased number of operational aircraft.

The basic value of the field trips was to gain an understanding of the operating environment of each system, the peculiarities of avionics maintenance which could bias the data and to review T.O.s, especially -2 manuals which contain intermediate repair procedures and test equipment lists and -4 Illustrated Parts

Breakdowns (IPBs) from which components counts were extracted. The use of formal questionnaires during base visits was originally proposed as an aid in the data collection effort. This idea was dropped due to the time required to collect and analyze the data; the limited time available at each base; and the loss of interest by technicians when presented with the questionnaire. Better results were obtained from face-to-face interviews. The maintenance personnel were more responsive when they could speak off the record. This discussion format resulted in better communications and aided in the identification of problem areas. The experience of individual technicians varies greatly, and is often limited to one MDS, and much of the data obtained via interviews is judgmental. Also, the limited number of operating bases visited, basically one per MDS, would tend to bias the data. For this reason telephone discussions with major command avionics management personnel were utilized to evaluate the trip results and to clarify certain points raised in the discussions.

Westinghouse Sources

Extensive use was made of many resources available within Westinghouse in performing this effort. The human resources utilized included engineers, logisticians and other specialized experts in the Integrated Logistic Support (ILS) Division and other Defense Center Divisions. Additionally, various data files, published technical reports, and engineering analyses were utilized. These resources were the preferred means of obtaining information since they were readily available and usable at minimum cost. Engineers were used to perform two functions; design analysis of Westinghouse systems and engineering analyses of technical data pertaining to other systems. The major Westinghouse systems looked at included the APQ-120 radar on the F4E, the Low Light Level Television on the B52H, and the ALQ-119 ECM pod and Pave Spike, ASQ-153. Among the design parameters identified and quantified were weights, volumes, power dissipation, and componentry technology. In addition, engineering personnel analyzed the definitions of input parameters for power dissipation, Built-In-Test/Fault-Isolation-Testing effectiveness, and componentry type and technology. For some LRUs, such as those in the F-4E digital scan converter group, Westinghouse engineers were able to obtain various design parameters from their counterparts in other companies whom they had previously interfaced with. One area of particular attention was the evaluation of power supplies; including the impact of tolerances and ripple on efficiency. As a result of these investigations and analyses, it was possible to obtain data not directly available from Air Force data systems and technical orders for inclusion in the data base.

Specialists in each of the logistic support technologies were consulted as part of the process for determining the model's support cost elements as well as sources of data and analytical

methodologies for use in the model. Recommendations on how to segregate the LRUs by avionics area was also obtained. In addition, computer specialist advised on the implementation of the LLSCFP, remote terminal data communications and programming techniques for the ALPOS.

The data sources identified and used within Westinghouse were F4E Systems Effectiveness Reports, raw 66-1 data on Westinghouse manufactured LRUs, field engineering reports and reliability and maintainability predictions. The Systems Effectiveness Reports provided a historical data base on various high cost LRUs for LSC. As with other data products, its usefulness is limited by the inclusion of only the top forty LRUs by LSC. The raw 66-1 data was used to provide a detailed failure data base. It was redundant with the data obtained from various Air Force reports and therefore was of limited use. Field reports were used to develop utilization factors and an operational scenario for the Pave Spike laser designator pod, the ASQ-153. They also were used to supplement the field visits in identifying problem areas. Reliability and maintainability predictions were used to establish the relative validity of the data obtained from the various data systems.

The technical data used was in two forms: Air Force T.O.s and published technical reports. The T.O.s are a part of the extensive library developed by ILS Engineering in support of Foreign Depot repair contracts. One important use of this Library was to supplement the data available at various Air Force bases. It was also used to screen the candidate LRU list for verification to determine which items had sufficient design data available for inclusion on the list. The technical reports reviewed fall into four areas: predictive operations and support, predictive acquisition, data system, and LCC. The main work in predictive acquisition, which was used as a basis for this model, was "Cost Analysis of Avionics Equipment", prepared by General Research Corporation for the Avionics Laboratory, (6) in the Bibliography. The Digital Avionics Study prepared for Aeronautical Systems Division, (1) in the Bibliography, uses the IROS cost calculation methodology in obtaining a minimum LCC curve. Thus it does not use design characteristics but rather requires maintenance data. The largest amount of literature was available in the area of predictive acquisition costs (1), (2), (3), (6), (7), (8), and (9) in the Bibliography. In general, these methodologies are less sophisticated in their approach to Regression Analyses than that used in the predictive model. A major work in the area of data systems was the Appraisal of IROS performed by the RAND Corporation, (4) in the Bibliography. Also used as references was the Preliminary Draft of the OSCER User's Manual and the report on the Visibility and Management of Component Support Costs, item (13) and (14) in the Bibliography. The Life Cycle Cost material reviewed covered the entire spectrum and the volumes are too numerous to mention here.

SECTION IV

DATA BASE DESCRIPTION AND DEVELOPMENT

This section describes the data elements used in the Regression Analyses, including their sources, and presents the suggested sources of those data elements used as inputs to the ALPOS model. The names and definitions of the thirty-five (35) elements in the data base are shown in Table 12. All of these data elements were used in the Phase I and/or Phase II analysis except for the number of integrated circuits and the number of SRUs per LRU which were included for a future investigation of complexity factors. For each LRU in the data base the value of each element is shown in Appendix B. Over 4500 values comprise this data base.

Appendix A summarizes a description of these data elements as well as other cost elements generated within the ALPOS model. This Appendix shows, for every data element, the definition or unit of measure for the element, the source(s) of the element, the variable name symbols used in the model and remarks, where appropriate. The ALPOS model requires only a limited number of these data elements for input. This includes aircraft type and avionics area indicator variables, LRU unit price, volume, weight, components count, power dissipation, component type, percentage solid state utilization factor, BIT/FIT factor (currently Phase I relationships only) and NRTS (as an option for some Phase II relationships). The following discussion highlights important factors and methodologies associated with the development of the data base.

<u>LRU Unit Price</u> [Code: UP]

The unit price, was obtained from the standard cost specified in the File Maintenance Register of IROS, PN8L. For a given Model-Design-Series (MDS) and Work Unit Code (WUC) for a particular LRU, PN8L may show a number of different unit prices associated with a number of different National Stock Numbers and corresponding item names. These may or may not be a proper match for the LRU in question. Therefore it was necessary to initially eliminate, by inspection, all spurious entries in PN8L. In cases where more than one legitimate NSN having different unit costs was associated with an LRU, PN6L, Logistics Support Cost Ranking - FSN, of IROS was reviewed to determine which NSN was associated with the greatest percentages of failures for that WUC. That NSN and its corresponding unit cost was selected as the information used in the data base. The Federal Stock List was used as a source of the year corresponding to a particular NSN and unit cost. It should be noted that the cost shown in PN8L and the Federal Stock list are essentially the same. From observations and discussions with personnel that use the File Maintenance Register, it appears that unit price updates lag the issue date of the IROS microfiche by approximately one year. Factors used in adjusting the costs to 1976 dollars were obtained from the

TABLE 12

DATA BASE ELEMENTS

1. Bomber indicator variable (1 indicates Bomber aircraft)
2. Cargo indicator variable (1 indicates Cargo aircraft)
3. Sensory indicator variable (1 indicates sensory avionics)
4. Communications indicator variable (1 indicates comm avionics)
5. Unit Price [UP]
6. Volume (in^3) [V]
7. Weight (lbs) [W]
8. Component Count [CC]
9. Percentage Digital Components [FDI]
10. Percentage Analog Components [FAN]
11. Percentage Electro-Mechanical Components [FEM]
12. Percentage Power Supply Components [FPS]
13. Percentage Transmitter Components [FXR]
14. Percentage Solid State Components [FSS]
15. Power Dissipation (watts) [PD]
16. Utilization Factor (Operating hours/flying hour) [UF]
17. Percentage Failures Detected by Automatic Test (BIT/FIT Factor) [BF]
18. Number of Integrated Circuits
19. Number of SRU's in the LRU
20. Mean Time (flight hours) Between Failures
21. Mean Time (flight hours) Between Maintenance Actions
22. Maintenance Manhours - Scheduled (Organizational)
23. Maintenance Manhours - Unscheduled (Organizational)
24. Maintenance Manhours - Shop (Intermediate)
25. Logistic Support Cost - Field
26. Logistic Support Cost - Special Repair Center (Depot)
27. Logistic Support Cost - Packaging and Transportation
28. Logistics Support Cost - Condemnation Replenishments
29. Training Costs
30. Percentage LRU's Not Repairable This Station (%NRTS)
31. Flying Hours (FH) (to normalize MMH and LSC)
32. Percentage Condemned LRU's
33. Specialized Repair Activity (Depot) Costs
34. Quantity per Assembly
35. Flying hours (to normalize Training costs)

Wholesale Price Index, Electronic Components and Accessories. Unit prices in the data base range from $153 to $566,500. The variable name for this element in the model and equations is UP. The suggested source of this data element for use in the model is a validated predictive acquisition cost model. In the absence of such an estimate, the next best source is engineering judgement from an experienced design engineer.

LRU Volume [Code: V] and Weight [Code: W]

Volume and weight of the LRUs were obtained primarily from the Field Maintenance Instructions, "-2" or or similar Technical Orders (T.O.s) reviewed during the base visits to the various component repair/avionics maintenance squadrons or obtained from within Westinghouse. For some LRUs in the data base, however, volume and/or weight could not be found in the T.O.s reviewed. Therefore, it was necessary to refer to other sources, such as the Navigational Equipment Handbooks published by ARINC Research, Incorporated. In a few cases actual measurements were performed on units awaiting repair during the field visits. It should be noted that the weight shown in IROS PN8L is the shipping weight which includes packaging material and, consequently was not used. In the data base, volumes range 30 cubic inches to 8200 cubic inches and weights range from 1 pound to 173.7 pounds. The variable names V for volume and W for weight are used for these elements in the model and equations. The suggested source of this data element is the experienced judgement of the design engineer.

LRU Component Count [Code: CC]

To obtain the count of electrical components, the Illustrated Parts Breakdown (IPB) in the "-4" T.O. (or similar T.O.) was reviewed and the number of active and passive electrical components such as resistors, capacitors, tubes, transistors, diodes, relays, motors, integrated circuits, etc. were tallied. Electrical connectors were not included in this count. The possibility of utilizing the Master Materials List produced through the DO49 data system to determine components count was investigated. It was discovered that these lists were not maintained on hard copy, but that the information would have to be accessed from a computerized system. It became apparent that in order to properly retrieve the list of components for all subassemblies of the LRU, a review of the IPB would first be necessary to identify the subassemblies. It was decided, therefore, that a more reliable count of components for the numerous LRUs under consideration would be obtained through a "first-hand" examination of the IPB. This served as a basis for the derivation of components density, defined as component count per unit volume, and the classification of component type and component technology. The component count ranges in the data base are from 9 to 8299 and components density ranges from .005 to 6.67. The variable name for component count and component

density in the model is CC and CD, respectively. The suggested source of this data element is engineering judgement based on prior systems.

<u>LRU Component Type</u> [Codes: FDI, FAN, FEM, FPS, FXR]

All of the LRUs in the data base were categorized by five different component types, that is, digital, analog, electro-mechanical, power supply, or transmitter. The characteristics which can be used to segregate component types are the types of components used, such as motors, integrated circuits, klystrons, etc., and the power levels at which they operate. Some units are of only one type, while many include a number of functions within the unit. The basic determination of the fraction of the unit devoted to each function was made by analyzing the various figures of the IPB and then using the fraction of the active components devoted to the function. Active components are defined, for this purpose, as tubes, transistors, integrated circuits, MEDs, diodes, relays, motors and assemblies. Assemblies, printed wiring boards, amplifiers, oscillators, etc., if not broken down in the IPB, were assumed to have four active components. With this methodology, therefore, it was possible to define the componentry of an LRU with any mixture of these five types. It should be noted that this resulted in five independent variables in the data base associated with specifying the types of components or LRU. Approximately 35% of the LRUs were classified as having some percentage of digital components, with the majority of LRUs having analog components. The variable names for the components types used in the model and equations are: FDI for digital, FAN for analog, FEM for electro-mechanical, FPS for power supplies and FXR for transmitters. The suggested source of this data element is an analysis of the functions to be performed by the proposed hardware.

<u>LRU Technology</u> [Code: FSS]

Two approaches to defining a technology level in addition to component types for an LRU have been investigated as part of the ALPOS development effort. This has involved the determination of the percentage of solid state components in the LRU as well as the average number of gates in the typical integrated circuit (IC) in the LRU (if applicable). For the current effort, the percentage solid state was used as an independent variable in the regression and is required as an input to the model, the variable name being FSS.

In an attempt to further define LRU technology using the number of gates, various electronics categories were examined. Some data was collected based on the assumption that for the LRUs from aircraft now represented in the regression data base, the integated circuits used technology available six years ago. From this investigation, along with interviews of ALC technicians and

various manufacturers' field engineers it was concluded that for most ICs in the LRUs now in the data base, the level of integration is considered small scale, with some medium scale integration and only a few LRUs having ICs with large scale integration. Except for a few of the LRUs, it was not possible to determine the exact number of gates per IC. A review of an article published in IDA Paper P-1296, "Proceedings of Symposium on Utilization of Large Scale Integrated (LSI) Circuits in Military Systems," confirms the indications gained from data collection experience. That is, for the most part, the average number of gates per IC in fielded equipment is in the area of 10, which is considered small scale integration (SSI). This was determined from a chart showing the projection of IC gate density from 1966 into the 1980's based on IC state-of-the-art versus the current trend using standard function IC's. There are, however, DoD initiatives being taken to increase the use of LSI (140-900 gates per chip) and very large integrated (VLSI) or very high speed integrated (VHSI) circuits (>900 gates per chip) in avionics systems to reduce life cycle costs. Some projections indicate that by 1985 it will be possible to produce, in quantity, signal processing modules, which now include over 100 MSI parts, in a single VHSI circuit of over 20,000 gates. To project the impacts of very high degrees of circuit integration on downstream support costs at the LRU level is a complex matter requiring further investigation. For this reason and the fact that VLSI circuits have numbers of gates per chip that are orders of magnitude greater than the SSI or MSI in the data base, the present stage of ALPOS development does not include the number of gates as an input parameter. It may be desirable to directly address the impact of LSI and VLSI by developing an algorithm, at some later date, which is not based solely on regression analysis. This aspect is further discussed in Section VIII as part of a model enhancement. It should be noted, however, that the effect of larger scale integration on LRU weight, volume, components count and power dissipation, variables already considered in ALPOS, will impact the results of the estimating relationships when evaluating design alternatives.

<u>LRU Power Dissipation</u> [Code: PD]

In all but a few of the T.O.s reviewed, there was no direct specification of the power dissipation. The development of this information, therefore, required additional analysis and, in some cases, certain assumptions depending upon the type of equipment. In the communications equipment area, both receivers and receivers/transmitters (R/T) are in the data base. For receivers, either tube or solid state, all input power is dissipated in the form of heat. For R/T units it was assumed that the unit will be used as a transmitter about 1% of the time. In the case of solid state units, only the receive power was assumed to be dissipated. For units with tubes in the transmitter, and assuming these units are in standby at all

times, then the heat dissipated will equal the receive plus transmit input power minus the power output of the transmitter. Navigational systems were assumed to be operating as receivers and transmitters continuously. Power dissipation was assumed to be input power minus transmit power. It is realized that, especially for Bombers on long missions, some of the navigational systems will be turned off during various portions of the flight. No reliable detail data was collected on the individual LRU utilization rates. In discussions with Boeing, Wichita, we learned that they too have been seeking this information for the B-52 and have been unable to define this factor.

Both communication and navigation units frequently have built-in power supplies. These were not considered separately for three equipments. Where a power supply is a separate unit and only input power is given, the power dissipation was assumed to be 50%. In one case (APN-81) a power supply and an amplifier were both considered. The total input power was given. It was assumed that the power dissipation was evenly divided between the two units.

Such units as amplifiers, computers and similar equipments were assumed to dissipate all input power as heat. Radar transmitter T.O.s usually have power inputs and outputs listed so that the dissipation could be readily determined. Electro-Mechanical devices were assumed to dissipate all input power. This type of device operates only intermittently. There is little power dissipation when it is not operating. A figure of 100 watts was assumed for the heat dissipation of this type of equipment. When no information on power or heat dissipation was available, an examination of the type of equipment, type of components (tubes or solid state) and the active component count was compared with similar systems where data was available. A power dissipation based on the proportions of active components was then assumed for this analysis. The power dissipations in the data base range from 3 to 3000 watts. The variable name used for this element in the model and equations is PD. This data element should be obtained through engineering judgement.

<u>LRU Utilization Factors</u> [Code: UF]

The development of a utilization factor, defined as the ratio of the LRUs operating hours to aircraft flying hours, was discussed with a number of personnel in systems and item management and at the base sites visited. It was decided that the development of a specific factor for each LRU in the data base was not feasible at this time. It should be noted, however, that for two digital retrofitted LRUs from the F-106, actual studies had disclosed a utilization of 3.1:1, which was used in the data base. For the other LRUs in the data base, more general utilization factors

such as those employed in Optimum Repair Level Analysis (ORLA) were considered based on the aircraft type. The utilization factors decided upon are as follows:

Fighter 2.3:1
Bomber 1.3:1
Cargo 1.2:1
ECM 0.3:1 (On any A/C type)

These utilization factors were used to adjust the flight hours for a particular MDS as shown in the AFM 66-1 "6-LOG" data product to operating hours. The resultant operating hours were then used to normalize the LSC and MMH to the dependent variables, LSC/OH and MMH/OH, used in the Regression Analyses. Also, the utilization factor was used as an independent variable in the regressions. The variable name used for this element in the model and equations is UF.

<u>LRU BIT/FIT Factor</u> [Code: BF]

In Phase I an investigation was performed to determine the source(s) of data which were available to provide a quantitative measure of Built-In-Test/Fault-Isolation-Test (BIT/FIT) capabilities for each of the LRUs in the data base. Although information could be obtained for some LRUs which was related to the design intent of BIT/FIT this would not provide a standardized measure for all LRUs of what was being achieved in the field. It was determined that the best common indication of BIT/FIT capabilities could be obtained from the "27-LOG" or "5-LOG" report. In this report, the percent of failures classified by the How Malfunction Code "failed automatic test" is shown. For each LRU in the Phase I data base, this percentage was extracted from the "27-LOG" report and used in the regression as the BIT/FIT variable. The ordering of the "27-LOG" required approximately a one month lead time.

For the phase II effort, the 5-log report was also used as a supplementary source to expedite obtaining this data. Nevertheless, problems were encountered in obtaining this data for approximately 11 LRUs and for some LRUs the percentage was 0 or very low whereas it was anticipated that the percentage detected by automatic test would be high.

Consequently, an investigation was made to determine if any Air Force studies had identified other means of arriving at BIT/FIT effectiveness measures. It was learned that one study (in progress) had identified 25 different measures of testability and BIT used by various contractors and, after evaluation, standard usages would be recommended. Also, it was learned that a study project was underway within the Air Force involving the survey of many systems with BIT and the determination of effectiveness

figures. The results of these studies unfortunately were not available when the regression data base was being finalized. Since the "failed auto test" percentage was not available for many of the LRUs, and questionable for some others, it was decided not to include this percentage as an independent variable in the regression analysis for the primary set of the estimating relationships for Phase II. It was not possible in this Phase to regress on a subset data base consisting of the more reliable failed auto test percentages as an independent variable in order to develop optional relationships. Therefore, the percent of failures detected by BIT is currently used as input only for the Phase I relationships. It should be emphasized that this input does not represent the BIT effectiveness predictions commonly used; but rather is obtained from an estimate of the actual field percentage of failures that would be detected by BIT.

Indicator Variables

Depending upon the aircraft type and avionics area associated with a particular LRU, indicator (or dummy) variables were coded in the data base. For aircraft type, the indicator variables were used to signify that the LRU was installed in either a fighter (F), bomber (B), or cargo (C) aircraft. A "1" is used to indicate either a bomber or cargo aircraft. A fighter aircraft is implied by both bomber and cargo being coded as "0". For simplicity, the aircraft type input to the ALPOS model is denoted by either an F, B, or C. The variable name used in the model for aircraft type is AC.

The avionics area is coded in the data base with either a "1" for sensory (S) or communications (C) avionics. Navigation (N) equipment is implied when both sensory and communications are coded as "0". The variable name in the model for avionics area is AA and either an S, C, or N is required for input. This set of indicator variables was used in the regression analysis to develop indicator variables to denote interactions between the aircraft type and avionics area. The relationships developed in Phase I use indicator variables which signify the following interactions:

a. LRUs in bomber aircraft communication systems.

b. LRUs in bomber aircraft sensory systems.

c. LRUs in cargo aircraft communication systems.

The Phase II relationships use indicator variables for significant interactions including:

a. LRUs in fighter aircraft navigation systems (baseline).

b. LRUs in fighter aircraft sensory systems.

c. LRUs in fighter aircraft communication systems.

d. LRUs in bomber aircraft navigation systems.

e. LRUs in bomber aircraft sensory systems.

f. LRUs in bomber aircraft communication systems.

g. LRUs in cargo aircraft navigation systems.

h. LRUs in cargo aircraft communication systems.

These indicator variables are automatically set in the ALPOS model depending on the aircraft type and avionics area input data for the LRUs in a particular system. The reader may refer to Volume II for a more thorough discussion concerning the development of these indicator variables.

LRU Logistic Support Cost (LSC)

The total annual LSC and elements of LSC for each LRU in the data base was derived from IROS data products. IROS microfiche for the two twelve-month periods ending March 1977 and June 1978 were used in the Phase I and Phase II efforts, respectively. This PN3L data product shows by WUC the total LSC per month for the current quarter along with the LSC per month for the three previous quarters. The PN4L data product provided on the same microfiche shows the breakdown for the current quarter of each element of the LSC; namely, the field maintenance cost, the specialized repair (depot) cost, the package and shipping costs and the condemnation costs. By computing the ratio of each element to the total for the current quarter and multiplying by the total annual LSC, an estimate of the annual value for each element can be obtained. These values were determined so that, if desired, regressions could be made to establish a relationship for each element of the LSC. In Phase I an estimating relationship was developed based on only the total LSC, whereas in Phase II relationships based on the field maintenance cost and total LSC were developed. For the regression analyses, the annual total or field LSC was normalized to LSC/OH by dividing by the appropriate operating hours (= flying hours x QPA x utilization factor).

Specialized Repair Activity (SRA)/Technical Repair Center (TRC) Standard Repair Cost

In the IROS data system, the total cost of SRA/TRC (depot) repair is calculated based on the number of units NRTS during the time period multiplied by the standard cost of TRC repair. This quantity is then multiplied by one minus the fraction of depot condemnations to obtain the total cost.

The standard TRC repair cost per unit is shown on the IROS PNBL, File Maintenance Register microfiche, and is obtained from the DSD HO36B, DMIF Cost Accounting/Product Report System. An estimating relationship for the parameter was developed in Phase II to provide some means of estimating depot repair costs. By using a procedure similar to that used in IROS, it would be possible to arrive at a predicted total depot repair cost for a given number of units NRTS over a certain time period.

LRU Maintenance Manhours and NRTS

The AFM 66-1 "6-LOG" data product obtained on microfiche for the six months ending September 1976 and March 1977 was the source of maintenance manhours for the LRUs in the Phase I data base. The manhours for the LRUs in the Phase II data collection was obtained from microfiche for the six months ending December 1977 and June 1978. The total scheduled, unscheduled and "shop" manhours are presented by WUC on this data product. These hours from both six-month periods were summed to obtain an estimate of the total annual maintenance manhours expended for both organizational and intermediate level maintenance on a particular LRU. In Phase I a relationship was developed based on the total maintenance manhours. Elements of the total; namely, unscheduled and shop manhours, were used in Phase II to develop associated relationships as well as the total manhours. For the regression analyses, the manhours were normalized to MMH/OH by dividing by the operating hours.

This same microfiche also shows the total shop maintenance actions taken, that is, the number of units either repaired, condemned or NRTS. The sum of these maintenance actions divided into the number of units NRTS results in the NRTS percentage shown for each LRU in the data base. This estimate of NRTS was generally consistent with the NRTS reported on the "27-LOG" and shown on COSPERANK.

LRU MTBF and MTBMA

The same AFM 66-1 "6-LOG" product shows by WUC the MTBF and MTBMA. Both are computed and shown for each month and then shown for the entire six month period. For the regression data base,

the average of the MTBF and MTBMA for both of the six month periods was used. The following formulas are used in the "6-LOG";

$$MTBF = \frac{\text{Flying Hours x Utilization Factor x OPA}}{\text{Quantity of Failure Occurrences}}$$

$$MTBMA = \frac{\text{Flying Hours x Utilization Factor x OPA}}{\text{Quantity of Total Maintenance Occurrences}}$$

In the "6-LOG" calculations the Utilization Factor is assumed to be 1.00. Therefore, to adjust the MTBF and MTBMA to an operating hour basis, they were multiplied by the utilization factors discussed previously.

LRU Training Costs

The Operating and Support Cost Evaluation Report (OSCER) was used as a basis for the derivation of LRU training costs. The OSCER shows trainng costs only to an MDS level; hence, a methodology for allocating costs to an LRU level was developed. This methodology relies primarily on ratios developed from the OSCER and IROS. First, for each MDS in the data base, the weapon system maintenance cost percent (WS%) of all maintenance and base operating (non-flying) support (BOS) costs was determined from the OSCER. This may be expressed by the following formula.

$$WS = \frac{\text{WS Maintenance Costs}}{\text{WS Maintenance Cost + BOS Costs}}$$

Second, the portion of training costs for weapon system maintenance (WS Training Costs) was calculated. In Phase I the total training costs were used whereas in Phase II only the costs of advanced formal training for technicians by the ATC was used in the calculations. Consequently in Phase I the formula was:

WS Train. Costs = WS x Total Nonflying Training Costs

and in Phase II the formula was:

WS Train. Costs = WS x Technical Course Training Costs

In order to allocate these costs to an LRU, the fraction of LSC for a particular LRU as shown in the IROS PN3L data product was used. This fraction is computed as follows:

$$\text{Fraction LSC} = \frac{\text{LRU Total LSC}}{\text{Total LSC for all LRUs in MDS}}$$

Consequently, LRU training costs may be expressed as:

LRU Train. Costs = Fraction LSC x WS Training Costs

In the report by Dodson (6), it is shown that training costs should be adjusted by a multiplication factor 350/280. This was determined based on the following statement:

> This average cost factor per man-week is $280, bounded by a minimum of $200 and a maximum of $350. For planning purposes, the $350 or maximum level is recommended for avionics training.

SECTION V

RESULTS OF THE MULTIPLE REGRESSION ANALYSES

The ALPOS Model is dependent upon a number of parametric and cost estimating relationships obtained by the technique of Multiple Regression Analysis. Six relationships were developed in Phase I and fifteen relationships were developed in Phase II. The basic concept of regression analysis is to estimate the value of a given variable, called the dependent variable (e.g. MMH/OH, MTBF, etc.) in terms of the known values of one or more other variables, called independent variables (e.g., unit price, weight, percent solid state, power dissipation, etc.).

The major reference used in this study on the subject of regression analysis is a book written in 1971 by C. Daniel and F. Wood called Fitting Equations to Data (15) which describes a computer program called the "Linear Least-Squares Curve Fitting Program" (LLSCFP). The proposals presented in this reference have been successfully discussed at many distinguished universities including Harvard, Princeton, MIT, Michigan State, Northwestern, Ohio State, Yale, New York, UCLA, Toronto and the University of Zurich as well as the Bell Telephone Laboratories and the National Cancer Institute. The LLSCFP has been the most sought after program in both the SHARE (IBM) and VIM (CDC) libraries of computer programs and has also been converted to run in East Germany and Russia. The applications of the LLSCFP cover a wide spectrum of the sciences including the agricultural sciences, management sciences, social sciences, and the biological sciences. It has also been used in environmental studies, exploratory research and the evaluation of moon rocks at the Johnson Space Center. Also in a Bureau of Labor Statistics study, the coefficients estimated by the LLSCFP were accurate to 15 digits. Thus, we feel that the approaches used are the "state of the art" in Regression Analysis.

The LLSCFP uses over thirty statistics, five types of plots and several tabular arrangements of the data to assist the analyst in developing the relationships and to determine the accuracy of the relationships obtained. An outline of the concepts of multiple regression analysis, including the statistics, plots and tables used is given in Volume II of the Phase I final report (16).

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15 "Fitting Equations to Data," Computer Analysis of Multifactor Data for Scientists and Engineers, Daniel, C. and Wood, F.S. the assistance of J. W. Gorman, Wiley, (1971).

16 Avionics Laboratory Predictive Operations and Support Model, Final Report, Volume II, E.E. Feltus, Ph D., March 1978.

The independent and dependent variables used to obtain the estimating relationships are given in Table 13 and Table 14. There are a total of twenty-one independent variables initially considered of which fourteen are quantitative (experienced over a range of values) and seven are qualitative (subjective). The qualitative variables are also called indicator variables (variables which take on the values of 0 or 1) and are used to introduce subjective information into the regressions covering such things as the type of aircraft in which the equipment is used (fighter, bomber, cargo) and the avionics area of the equipment (navigations, sensory, communications). The seven indicator variables considered are the interactive classes (e.g. sensory equipment used in a bomber, navigations equipment used in a fighter). Since FDI, FAN, FEM, FPS and FXR all add up to 1, it suffices to consider only four of these when performing the regressions. Without loss of generality, FAN was omitted from the regressions.

The twenty-one independent variables were chosen because of their assumed influence on Operations and Maintenance Costs. It is to be noted that these independent variables were not considered one at a time, in pairs or any other grouping but were all considered simultaneously in determining the effects on the dependent variables. The computer printouts of the LLSCFP were used to find the subset collection of the independent variables which "best" approximated the data. The regression analyses took into consideration the "goodness" of the data in addition to the assumed functional form of the equations. Both of these areas must be thoroughly analyzed in order to obtain accurate prediction equations.

TABLE 13
VARIABLES USED IN THE REGRESSIONS

INDEPENDENT VARIABLES		DEPENDENT VARIABLES
Indicator	Quantitative	Quantitative
IFIG * ISEN (=IFGSEN)	UP	MTBF
IFIG * ICOM (=IFGCOM)	V	MTBMA
IBOM * INAV (=IBMNAV)	W	MMH - TOT/OH
IBOM * ISEN (=IBMSEN)	CC	MMH - UNS/OH
IBOM * ICOM (=IBMCOM)	CD	MMH - SHOP/OH
ICAR * INAV (=ICRNAV)	FDI	LSC - TOT/OH
ICAR * ICOM (=ICRCOM)	FEM	LSC - FLD/OH
	FPS	SRA
	FXR	TRAIN/OH
	FSS	NRTS
	PD	
	UF	
	BF	

TABLE 14
DEFINITION OF VARIABLE NAMES USED IN THE REGRESSIONS

Independent Variables

Name	Definition
IFIG	Fighter indicator variable
IBOM	Bomber indicator variable
ICAR	Cargo indicator variable
INAV	Navigation indicator variable
ISEN	Sensory indicator variable
ICOM	Communications indicator variable
UP	Unit price
V	Volume (in^3)
W	Weight (lbs)
CC	Component count
CD	Component density
FDI	Percentage digital components
FAN	Percentage analog components
FEM	Percentage electro-mechanical components
FPS	Percentage power supply components
FXR	Percentage transmitter components
FSS	Percentage solid state components
PD	Power dissipation (watts)
UF	Utilization factor (operating hours/flying hours)
BF	Percentage failures detected by automatic test (Phase I only)

Dependent Variables

Name	Definition
MTBF	Mean time (operating hours) between failures
MTBMA	Mean time (operating hours) between maintenance actions
MMH - TOT/OH	Maintenance man hours - total per operating hour
MMH - UNS/OH	Maintenance man hours - unscheduled per operating hour
MMH - SHOP/OH	Maintenance man hours - shop per operating hour
LSC - TOT/OH	Logistics support cost - total per operating hour
LSC - FLD/OH	Logistics support cost - field per operating hour
SRA	Specialized Repair Activity (DEPOT) repair cost per unit
TRAIN/OH	Training cost per operating hour
NRTS	Percentage not repairable this station

The final form of the relationships developed through numerous iterations of analyses based on runs of the LLSCFP is shown in Tables 15 through 35 indicating the CERs and PERs obtained for each dependent variable. Note that three relationships in Phase II use NRTS as an independent variable with the initial intent of trying to determine the effects of different maintenance philosophies. Also, two relationships in Phase II are obtained via the Cp-search technique (see volume II) in order to find a subset collection of the variables which fix the date almost as well as the final set. Associated with each coefficient is a statistic called the t_i - value. The t_i - value is a measure of the accuracy of the coefficient estimated and is an indication of the inlfuence that independent variable x_i has on the fitted equation. Each coefficient uses the notation E $\pm$s to indicate the base 10 raised to the exponent s. (Example: E-02 = 10^{-2})

Tables 36 and 37 give a summary including four of the statistics used to evaluate the relationships for Phase I and Phase II, respectively. The multiple correlation coefficient squared R_y^2 (also called the coefficient of determination) is the statistic most widely used by statisticians to determine the "goodness of fit" of an obtained equation. The multiple correlation coefficient squared is a number between 0 and 1, where $R_y^2 = 1$ indicates a "perfect" fit and $R_y^2 = 0$ indicates a "bad" fit. The F-value is a statistic used in conjunction with a statistical hypothesis test called the F-test to determine the significance of R_y^2. The level of significance considered throughout this report is .01 (i.e., if R_y^2 is significant, there is a 1% chance of rejecting this significance). In general, the results for the Phase II regressions were "better" than the Phase I regressions. The only relationship where the Phase II fit was significantly worse was for the dependent variable NRTS (see Table 26 and Table 30). This was an expected and instructive result, however, because it is realized that policy decisions, not considered in the relationships, significantly impact NRTS.

TABLE 15

MEAN TIME BETWEEN FAILURES - PHASE 1

$$\ln(\text{MTBF}) = \sum_{i=0}^{14} V_i$$

V_i = COEFFICIENT	× INDEPENDENT VARIABLE	t_i-Value
V0 = 1.36551E+01		
V1 = 3.46281E-01	× X3M	2.1
V2 =-4.58243E-01	× X4M	2.9
V3 = 1.15374E+00	× X5	3.6
V4 = 6.34763E-01	× X6	1.9
V5 = 1.72434E-02	× FEM	6.1
V6 = 3.79188E-04	× (V-1484.0)	3.9
V7 = 9.88045E-03	× (FSS-61.0)	4.2
V8 =-6.18897E-08	× $(V-3337.0)^2$	2.3
V9 = 2.09706E-04	× $(FDI-43.08)^2$	1.8
V10= 1.88349E-04	× $(FSS-52.21)^2$	2.4
V11=-5.82664E-04	× $(BF-27.39)^2$	1.7
V12=-2.38566E-01	× Ln (UP)	3.9
V13=-6.25055E-01	× Ln (V)	2.9
V14=-4.60890E-01	× Ln (W)	2.9

WHERE:
X1M=IBOM-0.274
X3M=ISEN-0.258
X4M=ICOM-0.210
X5 =X1M×X3M
X6 =X1M×X4M

TABLE 16

MEAN TIME BETWEEN MAINTENANCE ACTIONS - PHASE 1

$$\ln(\text{MTBMA}) = \sum_{i=0}^{13} V_i$$

V_i = COEFFICIENT	× INDEPENDENT VARIABLE	t_i-Value
V0 = 9.85866E+00		
V1 = 3.15528E-01	× X3M	2.1
V2 =-3.13506E-01	× X4M	2.2
V3 = 1.45371E+00	× X5	4.9
V4 = 8.31176E-01	× X6	2.7
V5 = 1.17666E-02	× W	3.5
V6 = 8.26669E-05	× CC	1.6
V7 = 1.76838E-02	× FEM	6.5
V8 = 6.50037E-03	× (FSS-61.0)	3.1
V9 = 1.86436E-04	× $(FSS-52.21)^2$	2.8
V10= 7.32661E-07	× $(PD-729.0)^2$	2.6
V11=-4.83934E-04	× $(BF-27.39)^2$	1.5
V12=-2.83805E-01	× Ln (UP)	4.9
V13=-8.39866E-01	× Ln (W)	7.5

WHERE:
X1M=IBOM-0.274
X3M=ISEN-0.258
X4M=ICOM-0.210
X5 =X1M×X3M
X6=X1M×X4M

TABLE 17

TOTAL MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 1

$$MMHTOT/OH = \sum_{i=0}^{19} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 =-1.95115E-01	
V1 =-4.51221E-02 × X5	1.9
V2 =-7.74745E-02 × X6	2.9
V3 =-6.49006E-02 × X7	2.6
V4 = 1.62292E-03 × FDI	4.6
V5 =-3.34605E-04 × FSS	2.4
V6 =-6.61360E-05 × (V-1438.0)	5.4
V7 = 4.62871E-03 × (W-35.0)	7.0
V8 = 1.87208E-03 × (FAN-62.7)	5.4
V9 = 1.20082E-03 × (FEM-16.0)	3.5
V10= 1.54368E-03 × (FPS-3.43)	3.8
V11= 1.24928E-03 × (BF-4.83)	2.3
V12= 1.70110E-08 × $(V-3307.0)^2$	7.0
V13=-1.29283E-05 × $(W-64.4)^2$	2.5
V14=-3.33581E-05 × $(FAN-49.2)^2$	5.4
V15= 3.56802E-05 × $(FEM-46.4)^2$	4.5
V16=-8.38687E-05 × $(FPS-49.83)^2$	2.1
V17= 5.78168E-05 × $(BF-26.93)^2$	2.1
V18= 7.47867E-02 × Ln (V)	4.1
V19=-4.98197E-02 × Ln (W)	2.5

WHERE:
X1M=IBOM-0.286
X2M=ICAR-0.254
X3M=ISEN-0.254
X4M=ICOM-0.190
X5 =X1M×X3M
X6 =X1M×X4M
X7 =X2M×X4M

TABLE 18

TOTAL LOGISTICS SUPPORT COST PER OPERATING HOUR - PHASE 1

$$\text{Ln (LSCTOT/OH)} = \sum_{i=0}^{21} V_i$$

V_i = COEFFICIENT	×	INDEPENDENT VARIABLE	t_i-Value
V0 =-8,15108E+00			
V1 = 3,86111E+00	×	X1M	6.0
V2 = 3,66533E+00	×	X2M	5.6
V3 =-4,85271E-01	×	X3M	1.9
V4 =-2,56663E+00	×	X5	6.1
V5 =-1,66262E+00	×	X6	3.5
V6 =-7,67253E-01	×	X7	1.8
V7 = 1,27356E-02	×	FPS	2.6
V8 = 2,25967E-02	×	(FAN-63,3)	6.0
V9 =-7,42999E-03	×	(FSS-61,1)	3.0
V10= 2,38503E+00	×	(UF-1,64)	5.2
V11=-9,20384E-11	×	$(UP-133606,0)^2$	5.0
V12=-1,52864E-04	×	$(W-64,3)^2$	2.9
V13=-1,07105E-03	×	$(FAN-48,8)^2$	5.8
V14= 1,20418E-03	×	$(FEM-47,0)^2$	5.8
V15= 7,10025E-04	×	$(FXR-40,2)^2$	3.3
V16=-1,61651E-04	×	$(FSS-51,85)^2$	1.5
V17=-1,11568E-06	×	$(PD-722,0)^2$	2.7
V18= 5,00996E+00	×	$(UF-1,682)^2$	6.5
V19= 1,70042E-03	×	$(BF-27,26)^2$	3.6
V20= 4,60293E-01	×	Ln (UP)	5.6
V21= 2,35583E-01	×	Ln (V)	2.2

WHERE:

X1M=IBUM-0,286
X2M=ICAR-0,270
X3M=ISEN-0,254
X4M=ICOM-0,206
X5 =X1M×X3M
X6 =X1M×X4M
X7 =X2M×X4M

TABLE 19

TRAINING COST PER OPERATING HOUR - PHASE 1

$$\text{Ln (TRAIN/OH)} = \sum_{i=0}^{21} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value	
V0 = 2.02442E+01		
V1 = 7.47947E-01 × X1M	2.5	
V2 =-7.17271E-01 × X3M	2.1	
V3 =-1.37065E+00 × X4M	4.0	
V4 =-2.24068E+00 × X5	3.8	
V5 =-1.38297E+00 × X6	2.2	
V6 =-2.25394E-01 × FDI	2.6	WHERE:
V7 =-2.08437E-01 × FAN	2.3	X1M=IBOM-0.290
V8 =-2.07642E-01 × FEM	1.9	X3M=ISEN-0.258
V9 =-2.18839E-01 × FPS	2.4	X4M=ICOM-0.194
V10=-2.04514E-01 × FXR	2.4	X5 =X1M×X3M
V11= 2.38818E-04 × (CC-889.0)	2.5	X6 =X1M×X4M
V12=-3.09409E-04 × $(W-64.5)^2$	4.6	
V13=-1.61411E-07 × $(CC-2983.0)^2$	3.7	
V14=-4.98171E-04 × $(FAN-49.2)^2$	2.6	
V15= 4.94961E-04 × $(FEM-46.5)^2$	2.1	
V16=-1.42849E-03 × $(FPS-49.78)^2$	1.6	
V17=-4.95475E-04 × $(FSS-51.98)^2$	3.4	
V18=-1.39832E-06 × $(PD-724.0)^2$	2.3	
V19= 1.51222E+00 × $(UF-1.684)^2$	2.4	
V20= 1.93953E-03 × $(BF-26.94)^2$	2.9	
V21= 3.64906E-01 × Ln (UP)	4.1	

TABLE 20

PERCENTAGE NOT REPAIRABLE THIS STATION - PHASE 1

$$NRTS = \sum_{i=0}^{25} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 = 2.63934E+02	
V1 = 6.35414E+01 × X1M	2.6
V2 = 4.13039E+01 × X2M	1.8
V3 =-1.45530E+01 × X3M	2.0
V4 = 2.78727E+01 × X5	2.1
V5 =-1.52810E+00 × FPS	6.7
V6 = 1.90808E-02 × (V - 1475.0)	4.2
V7 =-2.84549E+01 × (CD - .938)	4.9
V8 =-1.41696E+00 × (FDI - 7.68)	6.1
V9 =-1.65207E+00 × (FAN - 63.5)	7.4
V10=-3.49197E-01 × (FXR - 11.1)	1.9
V11= 3.11855E+01 × (UF - 1.65)	2.0
V12=-2.91979E-06 × $(V - 3321.0)^2$	3.0
V13= 3.12925E-06 × $(CC - 2961.0)^2$	2.5
V14= 3.17105E+00 × $(CD - 2.508)^2$	2.2
V15=-4.19461E-02 × $(FDI - 43.08)^2$	3.1
V16= 5.32776E-02 × $(FAN - 49.5)^2$	3.7
V17=-3.35258E-02 × $(FEM - 45.7)^2$	2.4
V18=-5.15621E-02 × $(FXR - 41.0)^2$	3.5
V19= 3.63251E-05 × $(PD - 724.0)^2$	2.5
V20= 1.04189E+02 × $(UF - 1.684)^2$	3.0
V21=-9.80056E-02 × $(BF - 27.19)^2$	6.2
V22= 6.98140E+00 × Ln (UP)	2.7
V23=-6.34482E+01 × Ln (V)	5.9
V24= 3.84040E+01 × Ln (CC)	6.1
V25= 6.03601E+00 × Ln (PD)	2.4

WHERE:

X1M=IBOM-0.274

X2M=ICAR-0.274

X3M=ISEN-0.242

X5 =X1M×X3M

X5 = X1M × X3M

TABLE 21

MEAN TIME (OPERATING HOURS) BETWEEN FAILURES - PHASE 2

$$\text{Ln (MTBF)} = \sum_{i=0}^{23} V_i$$

V_i	= COEFFICIENT	× INDEPENDENT VARIABLE	t_i-Value
V0	= 1.57973E+01		
V1	= -7.76648E-01	× IFGCOM	3.5
V2	= -1.17318E+00	× IBMNAV	5.9
V3	= -1.20762E+00	× IBMCOM	5.0
V4	= -5.66108E-01	× ICRNAV	3.1
V5	= -1.19562E+00	× ICRCOM	5.2
V6	= -3.67444E-06	× UP	3.9
V7	= -2.22640E-01	× CD	5.1
V8	= 1.01840E-02	× FDI	6.7
V9	= 1.83455E-02	× FEM	6.5
V10	= 5.99593E-04	× (V-1281.0)	6.0
V11	= -1.05527E-02	× (W-31.2)	3.0
V12	= 1.32783E-02	× (FSS-79.0)	5.6
V13	= -3.05610E-01	× (UF-1.73)	2.5
V14	= -1.05947E-07	× $(V-3226.0)^2$	3.9
V15	= 1.27935E-04	× $(W-65.3)^2$	2.7
V16	= 2.21959E-04	× $(FPS-45.52)^2$	1.8
V17	= -1.48482E-04	× $(FXR-42.23)^2$	1.5
V18	= 2.26358E-04	× $(FSS-53.66)^2$	3.0
V19	= -4.12502E-07	× $(PD-975.0)^2$	3.2
V20	= -8.86055E-01	× $(UF-1.72)^2$	5.5
V21	= -2.41773E-01	× Ln (UP)	4.3
V22	= -9.24934E-01	× Ln (V)	6.5
V23	= -1.01741E-01	× Ln (PD)	2.0

TABLE 22

MEAN TIME (OPERATING HOURS) BETWEEN MAINTENANCE ACTIONS - PHASE 2

$$\text{Ln (MTBMA)} = \sum_{i=0}^{23} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 = 1.47077E+01	
V1 =-7.85726E-01 × IFGCOM	3.5
V2 =-1.17109E+00 × IBMNAV	5.9
V3 =-1.18391E+00 × IBMCOM	4.9
V4 =-5.71454E-01 × ICRNAV	3.1
V5 =-1.07055E+00 × ICRCOM	4.6
V6 =-2.81826E-06 × UP	3.0
V7 =-2.00878E-01 × CD	4.6
V8 = 8.02771E-03 × FDI	5.3
V9 = 1.82938E-02 × FEM	6.5
V10= 5.55100E-04 × (V-1281.0)	5.6
V11=-1.15558E-02 × (W-31.2)	3.3
V12= 1.12875E-02 × (FSS-79.0)	4.8
V13=-3.73066E-01 × (UF-1.73)	3.0
V14=-1.02032E-07 × $(V-3226.0)^2$	3.8
V15= 1.35063E-04 × $(W-65.3)^2$	2.8
V16= 2.21412E-04 × $(FPS-45.52)^2$	1.8
V17=-1.71495E-04 × $(FXR-42.23)^2$	1.8
V18= 2.11740E-04 × $(FSS-53.66)^2$	2.8
V19=-3.13309E-07 × $(PD-975.0)^2$	2.4
V20=-7.72170E-01 × $(UF-1.72)^2$	4.8
V21=-2.69229E-01 × Ln (UP)	4.8
V22=-8.00724E-01 × Ln (V)	5.6
V23=-1.06125E-01 × Ln (PD)	2.1

TABLE 23

TOTAL MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 2

$$\mathrm{Ln}\ (MMHTOT/OH) = \sum_{i=0}^{20} V_i$$

V_i = COEFFICIENT ×	INDEPENDENT VARIABLE	t_i-Value
V0 =-1,01402E+01		
V1 =-1,99281E-01 ×	IFGSEN	1.8
V2 = 5,94624E-01 ×	IFGCOM	3.2
V3 = 5,77750E-01 ×	IBMNAV	4.2
V4 = 7,13241E-01 ×	IBMCOM	4.5
V5 = 2,57158E-01 ×	CD	6.4
V6 =-4,49100E-03 ×	FXR	1.6
V7 =-1,63707E-02 ×	FSS	8.3
V8 =-1,31567E-02 ×	(FDI-24,9)	9.0
V9 =-2,48421E-02 ×	(FEM-10,2)	10.4
V10=-4,03887E-03 ×	(FPS-5,01)	1.8
V11= 5,86632E-12 ×	$(UP-187496,5)^2$	1.9
V12=-3,16774E-08 ×	$(CC-2955,0)^2$	2.7
V13= 1,49297E-04 ×	$(FDI-44,4)^2$	2.2
V14=-2,01240E-04 ×	$(FEM-44,8)^2$	2.7
V15=-1,62314E-04 ×	$(FPS-46,31)^2$	1.5
V16= 1,89762E-07 ×	$(PD-973,0)^2$	1.8
V17= 3,61428E-01 ×	$(UF-1,75)^2$	2.7
V18= 5,98173E-01 ×	Ln (UP)	13.5
V19= 1,88370E-01 ×	Ln (V)	1.8
V20= 3,78954E-01 ×	Ln (W)	3.3

TABLE 24

UNSCHEDULED MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 2

$$\text{Ln (MMHUNS/OH)} = \sum_{i=0}^{18} V_i$$

V_i	= COEFFICIENT	× INDEPENDENT VARIABLE	t_i-Value
V0	=-9.99109E+00		
V1	=-2.49989E-01	× IFGSEN	2.2
V2	= 3.40972E-01	× IFGCOM	1.7
V3	= 8.70714E-01	× IBMNAV	5.8
V4	= 4.94586E-01	× IBMCOM	3.0
V5	=-7.50874E-03	× FDI	5.1
V6	=-1.11264E-02	× FSS	5.3
V7	= 1.88862E-04	× (CC-1177.0)	4.4
V8	=-1.76952E-02	× (FEM-10.2)	7.1
V9	=-5.33356E-04	× (PD-335.0)	3.0
V10	= 2.14493E-08	× $(V-3245.0)^2$	1.5
V11	=-4.52237E-08	× $(CC-2955.0)^2$	3.4
V12	= 5.73676E-02	× $(CD-2.36)^2$	2.8
V13	=-1.62016E-04	× $(FEM-44.8)^2$	2.1
V14	= 3.43738E-07	× $(PD-973.0)^2$	2.6
V15	= 5.19028E-01	× $(UF-1.75)^2$	3.6
V16	= 4.63360E-01	× Ln (UP)	10.4
V17	= 3.07818E-01	× Ln (W)	4.1
V18	= 2.52781E-01	× Ln (PD)	3.5

TABLE 25

SHOP MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 2

$$\text{Ln (MMHSHOP/OH)} = \sum_{i=0}^{14} V_i$$

V_i = COEFFICIENT	× INDEPENDENT VARIABLE	t_i-Value
V0 =-1.14609E+01		
V1 = 8.42691E-01	× IFGCOM	3.5
V2 = 4.10211E-01	× IBMNAV	2.3
V3 = 9.39630E-01	× IBMCOM	4.6
V4 =-1.76397E-02	× FDI	9.9
V5 =-5.47801E-03	× FPS	1.9
V6 =-1.90886E-02	× FSS	7.8
V7 = 3.13922E-01	× (CD-1.22)	6.1
V8 =-3.23793E-02	× (FEM-10.2)	10.6
V9 = 7.34387E-12	× $(UP-187493.5)^2$	1.9
V10=-5.60418E-02	× $(CD-2.36)^2$	2.2
V11=-3.76169E-04	× $(FEM-44.8)^2$	3.9
V12= 2.43015E-01	× $(UF-1.75)^2$	1.4
V13= 6.70829E-01	× Ln (UP)	12.0
V14= 5.65786E-01	× Ln (V)	8.5

TABLE 26

TOTAL LOGISTIC SUPPORT COST PER OPERATING HOUR - PHASE 2

$$\text{Ln (LSCTOT/OH)} = \sum_{i=0}^{18} V_i$$

V_i = COEFFICIENT	× INDEPENDENT VARIABLE	t_i-Value
V0 =-7.97950E+00		
V1 = 7.85143E-01	× IFGCOM	3.2
V2 = 1.14876E+00	× IBMNAV	5.9
V3 = 1.07719E+00	× IBMCOM	4.6
V4 = 1.91500E-01	× CD	3.5
V5 =-1.22007E-02	× FDI	6.1
V6 =-1.72307E-02	× FEM	4.9
V7 =-9.49029E-03	× FXR	2.2
V8 =-8.36154E-03	× FSS	3.1
V9 =-3.35635E-04	× (V-1333.0)	3.0
V10= 1.98641E-02	× (W-32.3)	4.2
V11= 6.72593E-08	× $(V-3222.0)^2$	2.5
V12=-1.05350E-04	× $(W-65.3)^2$	2.0
V13=-4.24991E-08	× $(CC-2986.0)^2$	2.4
V14=-4.36525E-04	× $(FPS-45.48)^2$	3.1
V15= 7.79904E-01	× $(UF-1.72)^2$	4.1
V16= 5.64131E-01	× Ln (UP)	9.7
V17= 4.61602E-01	× Ln (V)	2.9
V18= 1.47264E-01	× Ln (PD)	2.5

TABLE 27

FIELD LOGISTIC SUPPORT COST PER OPERATING HOUR - PHASE 2

$$\text{Ln (LSCFLD/OH)} = \sum_{i=0}^{17} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 =-8.63885E+00	
V1 = 8.34904E-01 × IFGCOM	3.7
V2 = 8.53195E-01 × IBMNAV	4.7
V3 = 9.13951E-01 × IBMCOM	4.2
V4 = 1.32584E-02 × W	3.4
V5 = 1.99949E-01 × CD	4.0
V6 =-1.35760E-02 × FDI	7.2
V7 =-2.43521E-02 × FEM	7.7
V8 =-1.13244E-02 × FXR	2.9
V9 =-1.16312E-02 × FSS	4.7
V10=-2.74178E-04 × (V-1333.0)	2.7
V11= 3.58369E-08 × $(V-3222.0)^2$	1.5
V12=-3.84904E-08 × $(CC-2986.0)^2$	2.3
V13=-3.06241E-04 × $(FPS-45.48)^2$	2.3
V14= 6.56704E-01 × $(UF-1.72)^2$	3.7
V15= 5.20085E-01 × Ln (UP)	9.6
V16= 5.47207E-01 × Ln (V)	3.9
V17= 1.16195E-01 × Ln (PD)	2.1

TABLE 28

SPECIALIZED REPAIR ACTIVITY (DEPOT) REPAIR COST PER UNIT - PHASE 2

$$\text{Ln (SRA)} = \sum_{i=0}^{14} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i- Value
V0 =-2.07078E-01	
V1 =-6.77565E-01 × IFGSEN	4.6
V2 =-6.40011E-01 × IFGCOM	2.8
V3 =-2.64318E-01 × IBMNAV	1.7
V4 = 3.75071E-01 × IBMSEN	1.4
V5 =-2.76094E-01 × ICRNAV	2.0
V6 = 3.79270E-03 × FDI	2.5
V7 =-1.61279E-11 × $(UP-199034.4)^2$	4.3
V8 = 6.59084E-08 × $(V-3279.0)^2$	4.2
V9 =-2.77377E-04 × $(W-66.0)^2$	8.0
V10= 9.32045E-08 × $(CC-2730.0)^2$	5.9
V11= 3.68361E-04 × $(FEM-42.69)^2$	3.4
V12= 5.19716E-04 × $(FPS-46.82)^2$	3.9
V13= 5.59446E-01 × Ln (UP)	13.9
V14= 1.04766E-01 × Ln (CC)	2.3

TABLE 29

TRAINING COST PER OPERATING HOUR - PHASE 2

$$\text{Ln (TRAIN/OH)} = \sum_{i=0}^{24} V_i$$

V_i = COEFFICIENT	×	INDEPENDENT VARIABLE	t_i-Value
V0 =-7.69223E+00			
V1 = 7.13243E-01	×	IFGCOM	2.3
V2 =-9.69315E-01	×	IBMSEN	2.5
V3 =-1.10568E+00	×	ICRNAV	5.0
V4 =-6.32479E-01	×	ICRCOM	2.3
V5 =-5.16036E-06	×	UP	3.6
V6 = 9.87981E-03	×	W	2.4
V7 =-1.41283E-02	×	FDI	5.9
V8 =-3.70668E-01	×	UF	2.3
V9 =-4.82311E-04	×	(V-1345.0)	3.2
V10= 4.62847E-04	×	(CC-1191.0)	3.9
V11= 3.18476E-01	×	(CD-1.25)	2.1
V12=-2.17302E-02	×	(FEM-8.57)	4.0
V13=-6.89779E-03	×	(FPS-5.20)	1.8
V14=-1.47657E-02	×	(FSS-79.4)	4.4
V15= 7.04357E-08	×	$(V-3220.0)^2$	2.0
V16=-1.16361E-07	×	$(CC-2991.0)^2$	4.1
V17=-1.50232E-01	×	$(CD-2.37)^2$	3.2
V18=-4.24823E-04	×	$(FEM-43.07)^2$	2.6
V19=-6.70382E-04	×	$(FPS-45.7)^2$	3.6
V20=-2.08351E-04	×	$(FSS-54.2)^2$	1.6
V21= 6.22657E-01	×	Ln (UP)	6.8
V22= 1.11348E+00	×	Ln (V)	4.0
V23=-7.61468E-01	×	Ln (CC)	3.8
V24= 2.57936E-01	×	Ln (PD)	3.6

TABLE 30

PERCENTAGE NOT REPAIRABLE THIS STATION - PHASE 2

$$NRTS = \sum_{i=0}^{13} V_i$$

V_i = COEFFICIENT	× INDEPENDENT VARIABLE	t_i-Value
V0 = -4.25353E+01		
V1 = 3.99251E-03	× V	2.5
V2 = 1.27681E-01	× FDI	4.2
V3 = -3.07291E+00	× UF	1.8
V4 = -2.48616E-05	× (UP-39834.87)	1.7
V5 = -5.75510E-01	× (W-33.1)	5.4
V6 = 3.93942E-01	× (FEM-9.69)	9.2
V7 = 2.43035E-01	× (FXR-8.50)	3.5
V8 = 2.65801E-03	× $(W-66.9)^2$	2.8
V9 = 6.61377E-07	× $(CC-3018.0)^2$	2.2
V10 = 1.22326E-02	× $(FEM-44.09)^2$	6.7
V11 = 4.19589E-03	× $(FXR-42.50)^2$	2.6
V12 = -5.78248E+00	× Ln (V)	1.6
V13 = 1.76076E+01	× Ln (W)	4.0

TABLE 31

TOTAL MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 2 - WITH NRTS

$$\text{Ln (MMHTOT/OH)} = \sum_{i=0}^{20} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 =-9.41068E+00	
V1 =-2.03323E-01 × IFGSEN	1.8
V2 = 5.45295E-01 × IFGCOM	3.0
V3 = 6.19003E-01 × IBMNAV	4.6
V4 = 6.71232E-01 × IBMCOM	4.2
V5 = 2.18919E-01 × CD	4.2
V6 =-1.62102E-02 × FSS	8.2
V7 = 7.83621E-05 × (CC-1177.0)	1.5
V8 =-1.22770E-02 × (FDI-24.9)	8.6
V9 =-2.21381E-02 × (FEM-10.2)	9.4
V10 = 6.53446E-12 × $(\text{UP}-187496.5)^2$	2.2
V11=-3.58908E-08 × $(\text{CC}-2955.0)^2$	2.8
V12= 1.08496E-04 × $(\text{FDI}-44.4)^2$	1.6
V13=-1.68595E-04 × $(\text{FEM}-44.8)^2$	2.1
V14=-2.12327E-04 × $(\text{FPS}-46.31)^2$	1.9
V15= 1.76274E-07 × $(\text{PD}-973.0)^2$	1.7
V16= 3.31674E-01 × $(\text{UF}-1.75)^2$	2.5
V17=-3.98840E-03 × ENRTS	1.9
V18= 5.69582E-01 × Ln (UP)	12.7
V19= 1.79180E-01 × Ln (V)	1.7
V20= 3.13607E-01 × Ln (W)	2.9

TABLE 32

SHOP MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 2 - WITH NRTS

$$\text{Ln (MMHSHOP/OH)} = \sum_{i=0}^{14} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 =-1,12033E+01	
V1 = 7,69773E-01 × IFGCOM	3.2
V2 = 3,89169E-01 × IBMNAV	2.3
V3 = 8,43215E-01 × IBMCOM	4.2
V4 =-1,67864E-02 × FDI	9.6
V5 =-5,89773E-03 × FPS	2.1
V6 =-1,86613E-02 × FSS	7.8
V7 = 3,13626E-01 × (CD-1,22)	6.2
V8 =-3,03262E-02 × (FEM-10,2)	9.9
V9 = 6,92174E-12 × $(\text{UP}-187496{,}5)^2$	1.9
V10=-5,70397E-02 × $(\text{CD}-2{,}36)^2$	2.3
V11=-2,93880E-04 × $(\text{FEM}-44{,}8)^2$	3.0
V12=-6,56723E-03 × ENRTS	2.5
V13= 6,52610E-01 × Ln (UP)	11.9
V14= 5,55260E-01 × Ln (V)	8.5

TABLE 33

FIELD LOGISTIC SUPPORT COST PER OPERATING HOUR - PHASE 2 - WITH NRTS

$$\text{Ln (LSCFLD/OH)} = \sum_{i=0}^{16} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 =-5,92124E+00	
V1 = 6,90411E-01 × IFGCOM	3.2
V2 = 8,44373E-01 × IBMNAV	5.0
V3 = 7,34623E-01 × IBMCOM	3.5
V4 = 2,21346E-01 × CD	4.9
V5 =-1,15577E-02 × FDI	6.4
V6 =-1,96502E-02 × FEM	6.1
V7 =-7,38385E-03 × XR	2.2
V8 =-1,08125E-02 × FSS	4.6
V9 =-2,27836E-08 × $(\text{CC}-2986{,}0)^2$	1.7
V10=-3,10974E-04 × $(\text{FPS}-45{,}48)^2$	2.6
V11= 2,15236E-07 × $(\text{PD}-979{,}0)^2$	1.6
V12= 6,47959E-01 × $(\text{UF}-1{,}72)^2$	3.8
V13=-8,22418E-03 × ENRTS	3.2
V14= 4,77659E-01 × Ln (UP)	9.0
V15= 5,22663E-01 × Ln (W)	6.3
V16= 1,40378E-01 × Ln (PD)	2.5

TABLE 34

TOTAL MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 2 - Cp

$$\text{Ln (MMHTOT/OH)} = \sum_{i=0}^{18} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 =-9.96067E+00	
V1 =-1.82768E-01 × IFGSEN	1.6
V2 = 5.78793E-01 × IFGCOM	3.1
V3 = 6.38772E-01 × IBMNAV	4.7
V4 = 7.00564E-01 × IBMCOM	4.3
V5 = 2.60754E-01 × CD	6.5
V6 =-1.58170E-02 × FSS	8.0
V7 =-1.26715E-02 × (FDI-24.9)	9.2
V8 =-2.38675E-02 × (FEM-10.2)	10.2
V9 =-3.62713E-03 × (FPS-5.01)	1.6
V10= 5.60071E-12 × $(UP-187496.5)^2$	1.9
V11=-3.13052E-08 × $(CC-2955.0)^2$	2.6
V12= 1.40020E-04 × $(FDI-44.4)^2$	2.1
V13=-2.14439E-04 × $(FEM-44.8)^2$	2.8
V14=-1.82663E-04 × $(FPS-46.31)^2$	1.6
V15= 3.00104E-01 × $(UF-1.75)^2$	2.3
V16= 5.95772E-01 × $\text{Ln }(UP)^2$	13.3
V17= 2.20282E-01 × Ln (V)	2.1
V18= 2.99087E-01 × Ln (W)	2.8

TABLE 35

SHOP MAINTENANCE MANHOURS PER OPERATING HOUR - PHASE 2 - Cp

$$\text{Ln (MMHSHOP/OH)} = \sum_{i=0}^{13} V_i$$

V_i = COEFFICIENT × INDEPENDENT VARIABLE	t_i-Value
V0 =-1.13932E+01	
V1 = 8.16114E-01 × IFGCOM	3.4
V2 = 3.72241E-01 × IBMNAV	2.1
V3 = 9.04877E-01 × IBMCOM	4.5
V4 =-1.73658E-02 × FDI	9.7
V5 =-5.67557E-03 × FPS	2.0
V6 =-1.88572E-02 × FSS	7.7
V7 = 3.12671E-01 × (CD-1.22)	6.0
V8 =-3.21111E-02 × (FEM-10.2)	10.5
V9 = 7.41738E-12 × $(UP-187496.5)^2$	1.9
V10=-5.96390E-02 × $(CD-2.36)^2$	2.3
V11=-3.72212E-04 × $(FEM-44.8)^2$	3.8
V12= 6.65519E-01 × Ln (UP)	11.9
V13= 5.73330E-01 × Ln (V)	8.6

TABLE 36
CERS AND PERS DEVELOPED IN PHASE I

PARAMETER	SAMPLE SIZE USED IN FINAL PER	NO. OF COEFFICIENTS IN PER	R_y^2	F-VALUE
Ln (MTBF)	62	15	.9089	33.5
Ln (MTBMA)	62	14	.9183	41.5
MMH-TOT/OH	63	20	.9005	20.5
Ln (LSC-TOT/OH)	63	22	.9283	25.3
Ln (TRAIN/OH)	62	22	.8599	11.7
NRTS	62	26	.8200	6.6

NOTE: Ln indicates the natural logarithmic transformation of the parameter

TABLE 37
CERS AND PERS DEVELOPED IN PHASE II

PARAMETER	SAMPLE SIZE USED IN FINAL PER	NO. OF COEFFICIENTS IN PER	R_y^2	F-VALUE
Ln (MTBF)	120	24	.8851	32.1
Ln (MTBMA)	120	24	.8754	29.3
Ln (MMH-TOT/OH)	119	21	.9266	61.9
Ln (MMH-UNS/OH)	119	19	.8975	48.6
Ln (MMH-SHOP/OH)	119	15	.8997	66.6
Ln (LSC-TOT/OH)	117	19	.8827	41.0
Ln (LSC-FLD/OH)	116	18	.8809	42.6
Ln (SRA)	108	15	.8746	46.3
Ln (TRAIN/OH)	118	25	.8530	22.5
NRTS	116	14	.6630	15.4
CERs and PERs with NRTS as an independent variable:				
Ln (MMH-TOT/OH)	119	21	.9272	62.4
Ln (MMH-SHOP/OH)	119	15	.9035	69.6
Ln (LSC-FLD/OH)	116	17	.8909	50.5
PERs developed on basis of Cp search:				
Ln (MMH-TOT/OH)	119	19	.9233	66.9
NOTE: Power dissipation not required in this PER				
Ln (MMH-SHOP/OH)	119	14	.8977	70.9
NOTE: Utilization factor not required in this PER				

It is emphasized here that these are only three of over thirty statistics that are used to evaluate the fitted equations. As indicated in Volume II of this report, the multiple correlation coefficient squared, although widely used, is but one statistic and has little meaning to the analyst when considered alone. Valuable information can be extracted from the computerized plots and printouts of the LLSCFP to assist in obtaining the correct form of the equation, to determine if there is evidence of lack of fit of the equation obtained and to evaluate the stability of the relationships. Thus all measures of goodness of fit were considered simultaneously in developing the relationships.

SECTION VI

MODEL DEVELOPMENT

Although the regression analyses are the heart of model development, the computer programming effort is essential to establishing the PERS and other routines as a useful analytical tool. The model development involved creation of a Cost Breakdown Structure (CBS) to define operations and support costs, development of equations and computer coding to represent each cost, and creation of computer coding to tie the equations together and provide data input and output capability. Some notable features of the model are that the input data required has been minimized and oriented to conceptual parameters, CERs and other predictive techniques are integrated to provide a complete cost estimate, and the direct prediction of costs are made without intermediate calculations, reducing cumulative errors. Various elements of total LSC/OH and MMH/OH are, however, predicted for each design alternative.

Model Cost Breakdown Structure (CBS)

The structure of a LCC model is defined by the CBS used in constructing the model. A CBS is a tree, i.e. a network, which describes the various levels of cost and their organization. In this tree, the cost of any node is equal to the sum of the costs for the branches below that node, giving a hierarchical structure. The CBS for the Predictive O&S Model has been derived from those used in a number of previous models. The Air Force LSC model was used as a starting point, since it represents all of the support costs associated with an aircraft. The ten cost elements associated with the LSC model, at the second indenture level on the CBS tree, are:

1) Initial and replacement spares

2) On-equipment maintenance

3) Off-equipment maintenance

4) Inventory entry and supply management

5) Support equipment

6) Personnel training and training equipment

7) Management and technical data

8) New facilities

9) Fuel

10) Spare engines

In addition, four cost elements can be defined for operations costs:

1) Operator labor

2) Operator training

3) Power consumption

4) Operational data

For avionics support costs, two elements which can be immediately excluded from consideration are the cost elements for fuel and spare engines. The next cost element which can be excluded is the cost of new facilities. There are a number of reasons for this. First, this cost, if incurred, comes from a separate budget, Military construction, from the Operations and Support Budget. In addition the cost of facilities must be amortized across a long period, the life of the building, to be properly accounted for. At most bases, adequate facilities already exist to support the avionics shop. New facilities that may be required include items such as clean rooms, which cannot reasonably be apportioned to a single system, much less an LRU. Indeed, any additional facilities cost must be spread across all LRUs of an aircraft as it is impossible to justify the requirement for any one LRU. Another cost element that can be excluded is technical data or manuals. These also face the problem of apportioning from a system level to an LRU level in many cases. Although a few manuals cover only one LRU, the majority are written for an entire subsystem. In addition, operating and maintenance manuals include sections on support equipment and operating theory which cannot be properly apportioned to the LRU. Another area which causes problems is the manuals for support equipment, which may be applicable to a large number of LRUs in a system. In addition, our review shows that the cost and quantity of technical data is dependent on the presentation format and page layout. The last element to be deleted is the inventory management cost, which applies only to new stock-numbered items. Although this can be a significant cost in the absolute LSC of an item, the deltas between two competing LRUs tends to be insignificant. The components counts observed in the data base were, with a few exceptions, around 1000 total components. Gross differences from this number upwards resulted from the breakdown of non-repairable modules into components for purposes of uniformity. Assuming that each part occurs twice, a conservative estimate, there would be 500 different types of components. The review also shows that a majority of the components are Military specification items, which means that they are already in the inventory. Based on experience, an estimate of 10% for new items would be reasonable, giving a total of 50 new parts per LRU. This number is in close agreement with those obtained on the F-16 radar LRUs for the number of new parts. Although a large variance is seen between LRUs which perform different functions, items which perform similar functions are quite close. Using a

maximum expected variance of 10%, only a 5 parts difference would exist between alternatives, at a cost of less than $1000 per year. Thus, after excluding these five elements, the CBS to be used in the model includes the five most influential elements from the AFLC LSC model.

In the area of operations costs, especially for avionics, it is hard to apportion costs to an LRU. The three elements related to the operator, i.e. labor, training, and data, are usually buried in the pilots'/radar operators' or other crewmen's tasks. It is impossible to assign so much time to a task such as talking on the radio, dropping a bomb, or observing a radar when they are only parts of a larger group of tasks. Seldom will the number of operators affected by alternatives be evaluated by the model. The only exceptions that may be found are aircraft such as the E-3A Airborne Warning and Control System (AWACS) and the E-4A which contain massive amounts of avionics and a larger number of operators. The real benefits to be obtained in varying operator requirements are in the area of effectiveness and are beyond the scope of this model. Power costs are also difficult to define, even though a good estimate of power dissipation is required for the model. To convert an estimate of input power, in watts, to a cost requires a cost per watt for that power. Due to wide variances in the operational parameters encountered in flight, which affect the fuel consumption and efficiency of the engine, it is difficult to estimate a power cost per hour. Thus it is very difficult to estimate avionics operations costs and they are a small fraction of aircraft operating costs. Therefore, no operations costs are included in the model.

The model provides an estimate of the total of the following costs from the relationship for LSC/OH which is based on IROS data:

1) Replenishment spares

2) On-equipment maintenance

3) Off-equipment maintenance - base labor, depot labor, depot material, transportation

The total cost of training per operating hour is estimated using the relationship developed in Phase I and the cost of advanced technical training per operating hour is estimated using the Phase II relationship. The costs of spares and support equipment are calculated using the algorithms described below.

Spares Costs Calculations

Spares costs can be divided into two categories: initial and replenishment. Initial spares are those items procured to cover repair and transportation pipelines. In the model, initial spares are calculated using an Expected Back Order (EBO) criteria. Replenishment spares are those items which are

procured to cover the replacement of items which are condemned. The cost for these spares is included in the IROS LSC.

A review of spares procurement policies shows that procurements made at different points in time, for different systems, use varying criteria to determine quantities. Historical data shows that the cost of initial spares can be quite high, making them an important element of support costs. Dodson's report included data which indicated spares costs to be 35% of the acquisition costs, with a range across equipment types from 26% to 55%. Also, there is a great discrepancy between costs obtained from the Institute for Defense Analysis (IDA) and the Aerospace Guidance and Metrology Center (AGMC). Historical data does not offer, therefore, a good basis for predicting spares costs. In the past, spares have been brought under separate contract from the prime system, although they come from the same budget. Often a separate production run was made, requiring additional set-up costs. Spares costs are also affected by the quantity procured, requiring learning curve adjustments to provide a common baseline cost from historical data. One result of these policies is that the levels of protection provided is not consistent between programs. A change in DoD policy which is now occurring requires, if possible, that spares be coproduced with the prime hardware. This means that the non-recurring costs are shared between the two areas, allowing the costs of each to be approximately the same. Any differences would be due to packaging and testing costs. Thus, a relationship between past and future procurements would be biased by these differences.

Spares quantities then are calculated using a spares computing routine based on EBOs and the Air Force supplied factors for the repair cycle times and turnaround times. This philosophy provides a common baseline for spares costs.

Initial spares can be divided into two categories, depot level and base level spares. Depot level spares are those items which are stocked at depot to cover the depot repair cycle times. Base level spares are those items which are stocked at the base to cover the base repair cycle time and order-ship time.

The EBO routine used in ALPOS requires three basic inputs: the number of systems procured, quantity per aircraft, and unit price per LRU. In addition, values can be input for aircraft per squadron and operating hours per aircraft per month. If these values are not input, the model assigns them default values based on historical data, as shown in Table 38. Two outputs of the regression, MTBMA and NRTS, are also used in the calculations. Four constants which were obtained from the AFLC LSC model and AFM 175-3 give the remaining data required to calculate spares, as shown in Table 39.

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TABLE 38
SPARES CALCULATION CONSTANTS
DERIVED FROM AFM 66-1/IROS DATA

COMMAND \ DATA ELEMENT	ACSQN Aircraft per sqn/wing/etc	OPHR Operating hours/ month/aircraft
SAC	17	34
MAC	18	55
TAC	75	21

TABLE 39
CONSTANTS FROM LSC MODEL AND AFM 175-3

BRCT	Base Repair Cycle Time	.33
DRCT	Depot Repair Cycle Time	1.84
OST	Order Ship Time	.50
EBOS	Expected Back-Order Criteria	.10

The first step in the calculation of spares is to calculate the number of squadrons to be support by the spares. This is equal to the number of systems divided by the systems (aircraft) per squadron, rounded down to the nearest integer.

NOSQN = NOSYS/ACSQN (1)

The next step is to calculate the number of failures per month at each site and at Depot. For each site, the equation is:

FSITE = (OPHR * ACSQN * QPA)/MTBMA (2)

where:

FSITE = The failures per month per site

OPHR = the operating hours per month per aircraft

QPA = The quantity of the LRU per aircraft

ACSQN = the number of aircraft per squadron/wing/etc.

MTBMA = mean time between maintenance actions

The equation for depot failures per month is:

FDEPOT = (OPHR * NOSYS * QPA)/MTBMA (3)

where:

FDEPOT = the failures per month at Depot

NOSYS = the number of systems procured

The next step is to calculate the mean number of failures expected during the resupply period, at both intermediate and Depot. For intermediate, the equation is:

LAMTS = FSITE * ([1-NRTS * BRCT + NRTS * OST) (4)

where:

LAMTS = the failures expected at each site during the resupply period

NRTS = fraction not repairable this station, i.e. sent to Depot

BRCT = base repair cycle time

OST = order-ship time

The equation for Depot is:

$$LAMTD = FDEPOT * (NRTS * DRCT) \quad (5)$$

where:

LAMTD = the failures expected at the Depot during the resupply period

DRCT = Depot repair cycle time

Spares quantities, XSITE for each site and XDEPOT at Depot, are calculated from LAMTS and LAMTD using the EBOs procedure. The total spares quantity is:

$$TSPARE = (XDEPOT + NOSQN * XSITE) \quad (6)$$

where:

TSPARE = the total spares quantity required

The spares costs is then simply the quantity required times the unit price of the LRU. Spares are procured against a given expected back order criterion, such as .1, which is often used in the LSC model. This criterion says that the average number of back orders per unit of time should not exceed .1. Because of the random nature of failures, this criteria can be related to the Poisson distribution that is classically used to describe the failure process. Thus EBOs can be calculated directly from the terms of the Poisson equation which has a mean equal to the Mean Time Between Failures (which can be related to MTBMA). Thus for each item a demand rate, based on equipment utilization, turnaround times, and the maintenance philosophy, will be developed, i.e. λt of the reliability equation:

$$R = e^{-\lambda t} \text{ or } P(n \text{ failures or less}) = \sum_{i=1}^{n} \frac{e^{-\lambda t}(\lambda t)^n}{n!}$$

Figure 3 shows the subroutine developed by Westinghouse for calculating EBO quantities.

```
      SUBROUTINE EBO (DEMAND, EBOS, X)
      X-Ø.
      PROB=EXP (-DEMAND)
      CUMPRO=Ø.
      XBO=DEMAND
1     IF (XBO.LE.EBOS) GO TO 2
      CUMPRO=CUMPRO+PROB
      XBO=XBO-1.+CUMPRO
      X=X+1.
      PROB=PROB*DEMAND/X
      GO TO 1
2     RETURN
      END
```

DEMAND = The expected number of demands in time T.

CUMPRO = The cumulative probability of having a spare when the spares quantity is X.

XBO = Achieved backorders.

EBOS = Standard established for expected backorders

X = Spares counter

PROB = Probability of the Xth failure

Figure 3. Subroutine to Calculate EBOS

Support Equipment Costs

It is difficult to measure support equipment costs based on historical data due to advances in support equipment technology over the past decade. These advantages have resulted in a shift in test philosophy from primarily manual testing, using "hot mock-ups" and common test equipment, and, finally, to the use of general purpose test systems, such as GPATS (General Purpose Automatic Test System) and COMETS (Computer Operated Multi-function Electronics Test Station), which are applied across all of the avionics in an aircraft. Indeed, at a depot, general purpose systems are used for many aircraft. The trend for the future, as exemplified by recent procurements such as the F-16 and solicitation from the Support Equipment System Programs Office, will be towards even more automation. In addition, a major portion of the support equipment costs attributable to a Line Replaceable Unit (LRU) are in the software and interconnecting device costs for Shop Replaceable Units (SRUs).

Modern avionics systems concepts have virtually eliminated the use of flight line Aerospace Ground Equipment (AGE). The replacement is the increased use of Built-In-Test (BIT), Fault-Isolation-Test (FIT), and Built-In-Test-Equipment (BITE), such as the C5A MADAR system. The objective of these concepts is the detection and isolation of between seventy and ninety-five percent of the system failures. The remaining failures are isolated using a skilled technician. The result is that the cost of organizational support equipment is included as a part of the hardware acquisition costs. Thus, the model does not include any factor for flight line test equipment.

At the intermediate level, the trend is towards a quick turnaround of LRUs via removal and replacement of SRUs. The repair of SRUs is then relegated to the depot. An Example of an aircraft using this system for a number of LRUs is the F-16. Thus, equipment at this level will consists of an Avionics Intermediate Shop (AIS) which is usually divided into automatic and manual test stations. The automatic test stations are used to test the digital portions of the avionics, while the manual is used for electro-mechanical and some Radio Frequency (RF) items. On the F-16, the AIS consists of four test stations; the Computer/Inertial Station, the Digital/Indicator Test Station; the Pneumatic/Processor Test Station and an RF Test Station. These items are expected to be able to isolate ninety percent of the LRU failures to an SRU. The remaining LRUs will be sent to Depot. Conversations with personnel associated with older systems, such as the B-52 and F-4, indicate that the maintenance of avionics on these aircraft is swinging towards the same philosophy. When the number of personnel and the facilities needed to support system oriented support equipment versus common test stations is considered, it appears that future systems will

use this concept. Thus the cost at intermediate, except for the "sunk" costs for the test stations, is tied-up in interconnecting hardware and test software. The complexity and hence the cost, of these items is a function of the capability of the test equipment and the partitioning of the LRU. If the test equipment does not have a function required by the LRU, the interconnecting device will have to include such additions as additional buffering, to meet speed requirements, or signal conditioning. The complexity of the software will be based on the number of SRUs to be isolated to and the complexity of each. Since these design parameters are not fixed in the conceptual phase, it is impossible to estimate the costs.

At the depot level, the trend is towards the use of automatic test systems to isolate a component. For non-digital avionics, the trend is towards LRU or SRU dedicated computer operated test systems, such as an antenna test set or a high voltage power supply test set. Thus for digital items the cost is for interconnecting hardware and software. The same problems in estimating the cost of these items at intermediate is faced at Depot. For other devices, which may not use common test equipment, the cost of test equipment was not determined since the data gathering effort did not include the avionics Depot.

To summarize the area of support equipment, this investigation did not yield a relationship between the conceptual parameters and support equipment costs which is significantly better than existing models. It did show that the trend is towards more digital equipment (it is estimated that sixty percent of the functions in an avionics system are digital), requiring computer testing, that older philosophies, using common items such as oscilloscopes and multi-meters, are being replaced by the use of ATE and BIT/FIT, and that test requirements vary sufficiently among hardware items to greatly vary support equipment requirements. It should be noted, however, that the various models and techniques that will be developed as part of the Air Force's Modular Automatic Test Equipment (MATE) Program could later be used in conjunction with ALPOS.

Based on these results, the decision now is to use available historical estimating relationships, realizing their deficiencies. For the acquisition cost of support equipment, the best available estimate is contained in Dodson's report, which shows the acquisition cost of support equipment to be thirty-six (36) percent of the prime equipment acquisition costs. Although the data presented has a variance of twenty (20) percent and is limited to fourteen (14) Inertial Measurement Units (IMUs), a highly electro-mechanical device, it is better than that obtained from any other source. A review of various programs shows that this variance is not atypical of what occurs for other types of

equipment. For the cost for support of support equipment on an annual basis, the value used in the Air Force Logistics Command LSC Model, 10%, was chosen as a representative value. Data from other sources show that this figure can vary from seven percent, the cost of a warranty, to twenty percent, a Navy dictated value for a complex test station on a ship. Since the .1 figure was derived from field data, it is assumed to be the most representative value.

Computer Program

The ALPOS computer program, version 2, coded in the Fortran IV language for use on the CDC 6600 computer, has been developed to predict maintenance parameters and supports costs using PERs and CERs developed in Phase I and II. This section presents the framework which can be used, together with the other sections of the report, to create a user's manual. In addition, the data provided fulfills the documentation requirements of DI-H-5072A, following the guidance of MIL-STD-483, Appendix VI.

The model is divided into a number of routines, with a main routine to control the flows and a number of subroutines to perform the required calculations and format the output report. The coding of these programs is shown in Appendix D, together with flowcharts of each routine.

The main routine identified as PROGRAM ALPOS, contains the coding to input data, to develop the indicator variables for avionics area, aircraft type, and command, to set default values for aircraft per squadron or wing and aircraft operating hours per month, perform error checks, perform cost summations, and provide output reports. The input data is obtained from an input data deck which consists of the four card types. To reduce the amount of input data required, the indicator variables are input as alpha. For use in the PERs and CERs, the six values of indicator variables for avionics area and aircraft type must be converted to binary indicator variables. This task is performed in the section labeled expansion of variables. The default values of aircraft per squadron or wing and operating hours are set from mean values obtained from analysis of the Air Force data systems. The error checks evaluate the values of the indicator variables and set the values to default values. The results of the Phase II PERs and CERs for each LRU are summed to determine the subsystem total for a particular alternative. Also, cost summations accumulate the costs on an annual basis and a non-recurring basis for spares and support equipment.

The input data is formulated on five card types, as shown in Figures 4 through 8. The first type of card, which occurs only once per run, is the title card, which is used to input a title for the entire run. The second card type is the system card, which contains data on the platform in which the avionics is installed such as indicator variables and operational factors. For ALPOS, Version 2, the system card is also used to set switches for various input, calculation and output options. The PERs and CERs developed in either Phase I or Phase II by coding either a "1" or "2" in column 31. By coding a "1" in column 33, the value for NRTS is read as input from each LRU card and used for the spares subroutine; otherwise an estimate of NRTS generated from the PER is used. The option of exercising the PERs and CERs which use NRTS as independent variables is elected by coding a "1" in column 35. The names of the switches set in columns 31, 33 and 35 are CERSET, FNRTS and CKNRTS, respectively. The number of system cards which can be input in a single run must be one or more. For each system card a number of alternative and LRU data cards must be included in the data deck. The alternative card delineates the various alternatives, up to four separate alternatives. It contains a title for the alternative. For each LRU in the alternative up to a maximum of 20, an LRU data card is included with the sixteen input data parameters for use in the estimating relationships. It should be noted that the BIT/FIT factor is required as input only for the Phase I relationships. The final card is the continuation card, which is placed between systems to delineate continuation of the data. These five cards can be used to completely describe an input data deck as shown in Figure 9.

FORTRAN PROGRAM SHEET

TITLE: TITLE CARD - T

PROGRAMMER: TITLE OF RUN

DATE

Ø = ALPHABETIC O   0 = NUMERIC ZERO

I = ALPHABETIC I   1 = NUMERIC ONE

Ƶ = ALPHABETIC Z   2 = NUMERIC TWO

KEY | STATEMENT NO. | CONT | FORTRAN STATEMENT | SEQUENCE NO.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

```
TTEST OF ALPOS MODEL
```

COLUMN(s)	DESCRIPTION	FORMAT
1	CARD KEY	ALPHA - KEY IS "T"
2-21	RUN TITLE	ALPHA - NUMERIC

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

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PAGE OF

Figure 4. Title Card Format

FORTRAN PROGRAM SHEET

TITLE SYSTEM CARD - S

Ø = ALPHABETIC O | 0 = NUMERIC ZERO
I = ALPHABETIC I | 1 = NUMERIC ONE
Ƶ = ALPHABETIC Z | 2 = NUMERIC TWO

KEY | QTY | CM | AC | AA | ALT | NLPA | NLPA | NLPA | NLPA | OPHR | ACSQN | CERSET | FNRTS | CKNRTS | SEQUENCE NO.

```
S    53  3T F S 2   4   3                1
```

COLUMN(s)	DESCRIPTION	FORMAT	DEFAULT
1	CARD KEY	ALPHA - KEY IS "S"	
3-6	QUANTITY OF SYSTEMS	NUMERIC - INTEGER (I4)	
7	COMMAND	ALPHA - M, T OR S (FOR MAC, TAC OR SAC)	T
8	AIRCRAFT TYPE	ALPHA - C, F OR B (FOR CARGO, FIGHTER OR BOMBER)	F
9	AVIONICS AREA	ALPHA - N, C OR S (FOR NAV, COM OR SENSORY)	C
10	ALTERNATIVES	NUMERIC (NOT TO EXCEED 4) - INTEGER (I1)	
11-12	NO. LRUs PER ALT.	NUMERIC (NOT TO EXCEED 20) - INTEGRER (I2)	
13-14			
15-16			
17-18			
19-24	OPERATING HOURS PER A/C PER MONTH	NUMERIC (INPUT REQUIRED ONLY TO OVERRIDE DEFAULT) - REAL (F6.1)	
25-28	NO. A/C PER SQUADRON	NUMERIC (INPUT REQUIRED ONLY TO OVERRIDE DEFAULT) - INTEGER (I4)	
31	CERSET = 1	TO CALL PHASE 1 PERs AND CERs	
	= 2	TO CALL PHASE 2 PERs AND CERs (1 or 2 MUST BE CODED)	
33	FNRT = O OR SPACE	TO CALL PER SUBROUTINE FOR CALCULATING VALUE OF NRTS	
	= 1	TO USE INPUT VALUE OF NRTS IN ONLY SPARES SUBROUTINE OR, WHEN CKNRTS = 1, TO USE INPUT VALUE OF NRTS IN BOTH SPARES AND PER SUBROUTINES	
35	CKNRTS = 0 OR SPACE	TO CALL PER SUBROUTINES NOT USING NRTS AS A DEPENDENT VARIABLE	
	= 1	TO CALL PER SUBROUTINES USING NRTS AS A DEPENDENT VARIABLE WHEN FNRT = 1	

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Figure 5. System Card Format

PAGE OF

FORTRAN PROGRAM SHEET

TITLE: ALTERNATIVE CARD - A

DATE

PROGRAMMER: NAME OF ALTERNATIVE

KEY

Ø = ALPHABETIC O | 0 = NUMERIC ZERO
I = ALPHABETIC I | 1 = NUMERIC ONE
Z = ALPHABETIC Z | 2 = NUMERIC TWO

STATEMENT NO. | FORTRAN STATEMENT | SEQUENCE NO.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

A L R U s F R O M A P Q - 1 2 0 F O R V A L I D A T I O N

COLUMN (s)	DESCRIPTION	FORMAT
1	CARD KEY	ALPHA - KEY IS "A"
6-80	NAME OF ALTERNATIVE	ALPHA - NUMERIC

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

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Figure 6. Alternative Card Format

FORTRAN PROGRAM SHEET

TITLE: LRU DATA CARD - L

Ø = ALPHABETIC O; 0 = NUMERIC ZERO; I = ALPHABETIC I; 1 = NUMERIC ONE; Ƶ = ALPHABETIC Z; 2 = NUMERIC TWO

KEY	ID	UP	VOL	WT	CC	FDI	FAN	FEM	FPS	FXR	ENRTS	FSS	PD	BF	UF	QPA
L	7 4 B C O	8 0 4 6	5 8 5	1 2 5	8 7 8		8 7	1 3				8 7	5 8	2	2 3	1
L	7 4 B E O	3 3 9 8	3 2 4	9 3	5 8				1 0 0			1 0 0	7 5	0	2 3	1

COLUMN(s)	DESCRIPTION	FORMAT
1	CARD KEY	ALPHA - KEY IS "L"
4-8	IDENTIFICATION	ALPHAS - NUMERIC
9-16	UNIT PRICE	NUMERIC REAL (F8.0)
17-22	VOLUME	NUMERIC REAL (F6.0)
23-28	WEIGHT	NUMERIC REAL (F6.1)
29-34	COMPONENTS COUNT	NUMERIC REAL (F6.0)
35-54	COMPONENTS TYPE	NUMERIC REAL (5F4.0)
35-38	PERCENT DIGITAL	
39-42	PERCENT ANALOG	
43-46	PERCENT ELECTRO-MECH	
47-50	PERCENT POWER-SUPPLY	
51-54	PERCENT TRANSMITTER	
55-58	PERCENT NRTS (OPTIONAL)	NUMERIC REAL (F4.0)
59-62	PERCENT SOLID STATE	NUMERIC REAL (F4.0)
63-68	POWER DISSIPATION	NUMERIC REAL (F6.0)
69-72	BIT/FIT FACTOR (PHASE I PERS)	NUMERIC REAL (F4.0)
73-76	UTILIZATION FACTOR	NUMERIC REAL (F4.2)
77-80	QPA	NUMERIC REAL (F4.0)

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Figure 7. LRU Data Card Format

PAGE OF

FORTRAN PROGRAM SHEET

TITLE CONTINUATION CARD - C

DATE

PROGRAMMER

KEY

Ø = ALPHABETIC O   0 = NUMERIC ZERO

I = ALPHABETIC I   1 = NUMERIC ONE

Ƶ = ALPHABETIC Z   2 = NUMERIC TWO

STATEMENT NO. | CONT. | FORTRAN STATEMENT | SEQUENCE NO.

```
C

      COLUMN          DESCRIPTION          FORMAT

        1             CARD KEY             ALPHA - KEY IS "C"

                      NOTE:  THIS CARD IS REQUIRED TO CONTINUE PROGRAM EXECUTION FOR A DIFFERENT SYSTEM.
```

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Figure 8. Continuation Card Format

PAGE OF

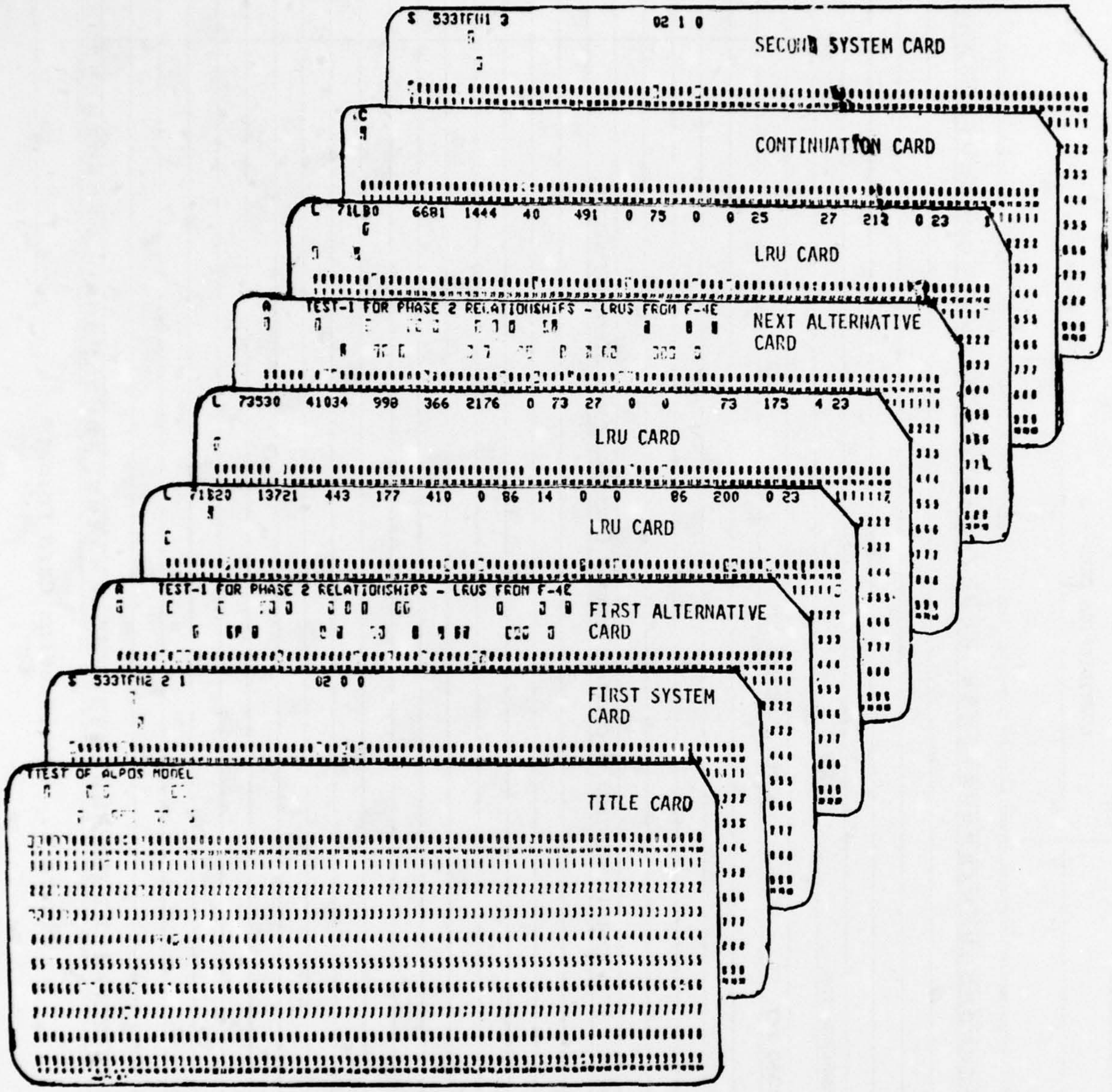

Figure 9. Sample Data Deck

The subroutine COVER contains the coding to print the cover to the ALPOS model output. It outputs the run title and date. The date is obtained through the CDC to 6600 operating system using the "CALL DATE" subroutine.

The subroutine PRINT1 is used to echo the input data for each LRU within an alternative. It prints a heading for each of the data elements, with the format of the actual data being a matrix with each LRU in one row and each data element in one column. When NRTS is input, the value is included in the echo printout. An example of the output of this subroutine is shown in Appendix D.

The subroutine ESTIM is used to predict the logistics support parameters based on the PERs and CERs developed in Phase I. It calls the five prediction subroutines: ESTMTF for estimating MTBF, ESTMTA for MTBMA, ESTLSC for LSC/OH, ESTMMH for MMH/OH and ESTTRN for total training costs per operating hour. In these prediction routines the interactions of the indicator variables are also calculated.

The subroutine ESTIM2 is used to predict some of the logistic support parameters based on PERs and CERs developed in Phase II. The interactions of the indicator variables used in these relationships are calculated in the main program and passed to each subroutine. ESTIM2 calls ESTMTF2 for estimating MTBF, ESTMTA2 for MTBMA, ESTLSC2 for total LSC/OH, ESTDEP2 for the standard cost of SRA (Depot) repair per unit, ESTMUN2 for unscheduled MMH/OH and ESTTRN2 for advanced training costs per operating hour. If both FNRTS = 1 and CKNRTS = 1, ESTLFDN, ESTMMHN and ESTMSHN are called in the main program to estimate field LSC/OH, total MMH/OH and shop MMH/OH, respectively, using the input value of NRTS as an independent variable in the estimating relationships. Otherwise, ESTLFD2, ESTMMH2 and ESTMSH2 are used to estimate these parameters.

Depending on the value of CERSET, ESTNRT or ETSNRT2 is called by the main program to estimate NRTS when NRTS is not a data input. The SPTEQ, SPARES and EBOS subroutines calculate the values of the support equipment and spares costs using the methodology described earlier in this section.

The flow within and between the various routines is shown in the flow charts of Appendix D. In addition, comments are included in the computer coding to self-document the flows and procedures.

The outputs of the computer programs consists of three parts: an echo of the input data for each system, an echo of the LRU input data for each alternative and an output summary of predicted factors and costs for each alternative. Examples of these sheets are shown in Appendix D. The system input variable and LRU input variable sheets are self-explanatory. The model output sheets present the calculated values of components density and the number of spares required, the results of the estimating relationships, the sub-system totals, the annual LSC, training

costs, and support of support equipment costs, and the non-recurring support equipment and spares costs. The subsystem (SS) MTBF and MTBMA is calculated using the following formula:

$$\frac{1}{MTBF_{SS}} = \frac{1}{MTBF_{LRU1}} + \frac{1}{MTBF_{LRU2}} + \ldots + \frac{1}{MTFB_{LRUN}}$$

$$\frac{1}{MTBMA_{SS}} = \frac{1}{MTBMA_{LRU1}} + \frac{1}{MTBMA_{LRU2}} + \ldots + \frac{1}{MTBMA_{LRUN}}$$

For each alternative a summary is provided of the annual and non-recurring costs of all LRUs. Components density is calculated from the volume and components count. The annual LSC and training costs are derived from the cost per hour multiplied by the expected number of operating hours per year.

SECTION VII

VALIDATION

An effort, commensurate with the overall scope of the project, was made to investigate the validity of the ALPOS model. The estimating relationships determined by the regression analysis for MTBF, MTBMA, MMH/OH, LSC/OH, NRTS, SRA and TRAIN/OH were the subject of this limited investigation since the associated analyses and data collection comprised the greatest portion of the project tasks. The relationships and methodology used to determine spares costs and support equipment costs have not been addressed in this validation effort. Their relationship to established procedures or investigation results have been commented upon in previous sections of this report.

Before discussing the validation approach and conclusions relevant to the ALPOS model, it is desirable to review the general concept of a mathematical model and the meaning of the term validity as it relates to both the model itself and the coding of the computer programs. It becomes apparent that in any modeling effort three major elements are of concern, namely; the real system, the model, and the computer. Also of concern is the means by which these elements are tied together. The term modeling refers to the relationships between real systems and models, while an encoded program establishes the relationship between the model and the computer.

More specifically, the real system dealt with for this project was the characteristics of Air Force avionics systems and the resultant logistics effects as measured by logistics support costs, MTBFs, MTBMAs and MMH/OHs, and reflected in the IROS and MDC data systems. The ALPOS model (version 2) contains the Fortran IV encoded program which provides the instructions for generating the logistics effects data as a function of the characteristics. For the development of these functional relationships or equations used in the ALPOS model, the modeling technique of multiple regression analysis was utilized as described in Volume II.

The validity of the ALPOS model deals with the modeling relationships, that is, how well the model, through the equations established, relates the avionics characteristics to the logistics effects. This assumes, however, that the model, as reflected in the computer program, duplicates the results of the regression analysis. The Fortran coding of the equations shown in Section V has been verified by inputting to the ALPOS model some of the same data used in the regression analysis. A number of trial runs of the computer program were made, each testing the different cases of input which set different values of the indicator and interaction variables. Key-punched and transcribing errors have been eliminated. The results generated by the ALPOS computer program duplicate the output of the

regression analysis program when like inputs are made to each program. Therefore, the correctness of the Fortran coding has been verified and the assumption underlying any discussion of validity has been satisfied.

There are various degrees of strength in demonstrating model validity, all related to a measure of the extent to which the real system data agrees with the model generated data. The basic measure of model validity is concerned with how well real system data, already acquired, matches model generated data.(17) A model providing "satisfactory" matching is said to be replicatively valid. In the case of the ALPOS model, a regression model, this measure relates to the "goodness of fit" of each functional relationship and the accuracy of the data base used in establishing the relationships. During the data collection process an effort was made to eliminate any spurious data by comparing alternate sources of information when accuracy seemed questionable. Also, the numerous discussions with technicians during the base visits provided expert assistance with the final selection of items in the data base and the interpretation of the associated data. The data base still reflects, however, any inherent weaknesses which may exist in the MDC and IROS data collection system.

The "goodness of fit" of a functional relationship obtained by regression analysis is not determined by any one statistic or statistical test, but by considering simultaneously all statistics, statistical tables, plots and techniques available to evaluate the relationships, i.e. one must evaluate the "total picture". Table 37 in Section V shows only a few of the statistics for each relationship obtained including one of the most widely used statistics which gives a relative measure of the "goodness of fit" called the multiple correlation coefficient squared, R_y^2. For a look at the "total picture", Volume II of this report contains all computer printouts for each relationship with most of the options of the LLSCFP employed.

The statistical results (i.e. statistics, plots, tables, techniques, etc.) for each of the relationships obtained, except NRTS, exceeded initial expectations concerning the "goodness of fit" obtainable with a data base encompassing so many independent variables (characteristics), each having values covering a wide range, in many cases over three orders of magnitude. Although the result for NRTS was barely satisfactory, it was not surprising. Other factors besides those used as independent variables in the regression analysis or those which may be known in the conceptual phase can impact NRTS. ALPOS, Version 2, allows either a direct input of NRTS or generates an estimate of NRTS from a PER. Where NRTS is required for input to the

17 "Theory of Modeling and Simulation," Bernard P. Ziegler, John Wiley and Sons, NY 1976.

Expected Back Order (EBO) routine to calculate spares costs, it is felt that the estimate provided for NRTS is acceptable in this application even though a relatively greater amount of error may be present in outputs obtained from this relationship than for the others. This opinion is based on the fact that only large differences in NRTS generally cause significant changes in the total number of spares estimated by the EBO routine. From the procedures followed in establishing the data base, performing the regression analysis and the "goodness of fit" statistics, it can be concluded that the relationships for MTBMA, MTBF, LSC/OH, MMH/OH, SRA and TRAIN/OH are replicatively valid.

The strongest measure of validity, the demonstration of which is wanting in most estimating models (accounting, subjective, regression, "crystal ball", etc.), is the condition in which the model is predictively valid, that is, when it can match real system data before the model has "seen" the data. For the ALPOS model, this is, of course, its reason for existence. In other words, the functional relationships in the model should be able to generate as outputs MTBFs, MTBMAs, MMH/OHs, LSC/OHs, SRAs and TRAIN/OHs based on inputs of the avionics LRU physical and electrical characteristics which are "similar" to the MTBFs, MTBMAs, MMH/OH, LSC/OH, SRAs and TRAIN/OHs found in the MDC, IROS and OSCER data system. The key word for this type of validity is similar.

Several approaches have been taken with the intent of demonstrating predictive validity for multiple regression analysis models, including running a totally new (validation) data base through the regression relationships obtained via the original data base, prediction intervals and cross verification of coefficients with a second sample of data. The correct way to attempt demonstrations of predictive validity for regression models is that of developing a new (validation) data base (of "approximate" size and complexity as that of the original data base) and run this validation data base through the regression equations (using the same functional form) developed. The analyst must then evaluate the "total picture" including coefficients, statistics, statistical plots and techniques to determine if there is a significant difference in the results using the validation data base. Obviously this approach is out of the scope of this particular study since the data collection and analysis effort comprises a large portion of the project tasks costs and man hours for model development.

A prediction interval (sometimes called a confidence interval) is an interval about which the analyst is confident (e.g. 95% confident) that the estimated value of the dependent variable (e.g. MTBF, MMH/OH, etc.) for a particular observation in the validation data base is within the bounds of the interval, where the lower the confidence level the smaller the interval. There are two major drawbacks in demonstrating predictive validity for multiple regression analysis models via the prediction interval approach. First, the prediction interval approach depends

heavily upon the assumption that the equation obtained through statistical analyses is the correct form of the equation. Although many types of analyses, based on the data available, have shown statistically significant results (as demonstrated through replicative validity), it is not definitely known that the regression equation obtained is the correct form. This has been demonstrated many times in the physical and social sciences, where equations that were used for many years were updated as new data and information became available. Secondly, a predictive interval is calculated for each observation in the validation data base one at a time, and hence, the "total picture" of the effects that the validation data base has on the coefficient, statistics, plots and tables cannot be evaluated. Prediction interval, however, has its merits when considering much less involved statistical methods of estimation than that of multiple regression analysis.

The approach used in this study for attempting the demonstration of predictive validity is cross verification of coefficients with a second sample of data. Basically the cross verification of coefficients approach involves adding the validation data base (which can be of any size from one observation to the amount of extra data available, the larger the better) to the original data base to obtain a second sample of data. A LLSCFP run is made with the second sample of data, using the same functional form obtained using the original data, where the coefficients using the original data are saved and can be compared with the coefficients obtained using the second sample. The change in the coefficients could be negligible, a 100% or more change could occur and a change in sign of the coefficients is also conceivable. The larger the change in the coefficients, the less stable the prediction equation. The analyst must also evaluate the "total picture" including such statistical plots as the component plus residual plots (where the residuals are calculated using the original coefficients) which may indicate that other forms of curvature are needed. Cross verification of coefficients is a rigorous test of the model, the data and the fitted coefficients. Volume II of this report includes a more indepth discussion of statistical implications of cross verification of coefficients with a second sample of data.

To investigate predictive validity it is then necessary to perform the same type of data collection required in establishing the data base for the regression analyses. That is, for each LRU to be included in the validation, all of the independent variables required as input to exercise the estimating relationships must be collected or derived. This implies that the process of reviewing technical orders or obtaining data from other sources to determine LRU weight, volume, power dissipation, components count, type and technology is again necessary. Also, it is necessary to collect data for the LRU dependent variables. This implies that data must be extracted and reduced from IROS, MDC 66-1 and OSCER concerning LSC/OH, MMH/OH, MTBF, MTBMA, NRTS, SRA and TRAIN/OH.

Since the results of the validation investigation conducted in Phase I were encouraging, it was decided that the six LRUs used in the effort should also be used in the Phase II validation to provide a common measure of validity. In addition to these six LRUs, five LRUs were selected for validation during the Phase II data collection. The combined validation data base for Phase II, therefore, consisted of 11 LRUs.

Based on data availability at the end of Phase I, it was determined that the best approach would require the use of LRUs from the APQ-120 radar which were not in the data base used for the regressions. Also, it was considered desirable to include in this validation LRUs from both an MDS and avionics sub-system not included in the Phase I regression data base. The F-111 was selected as the MDS fulfilling this objective. At that time the selection of the F-111 avionics sub-systems was dictated by local availability of technical orders. Fortunately, the T.O. for the ARN-52, the TACAN in the F-111E, was available in the Westinghouse library and the receiver-transmitter was selected for validation. Also obtained was the T.O. for the APX 76 IFF installed in the F-111D.

At the beginning of Phase II data collection, it was decided that LRUs not in fighter aircraft but in cargo and bomber aircraft, would be added to the validation data base. For this purpose, LRUs from te C-5A and FB-111A were selected. The LRUs used for the validation investigated in Phase II are summarized in Table 40.

TABLE 40
LRUS USED FOR PREDICTIVE VALIDATION IN PHASE II

MDS	A/N	Noun	WUC
F-4E	APQ-120	Synchronizer SN-413B	74BCO
F-4E	APQ-120	Power Supply PP-4847	74BEO
F-4E	APQ-120	Modulator MD-735	74BGO
F-4E	APQ-120	Amplifier AM-4827	74BHO
F-111E	ARN-52	Tacan RT-384	71BAO
F-111D	APX-76	IFF RT-868	65BAO
C-5A	APX-64	Transponder RT-731	65AAO
C-5A	APN-199	Loran Receiver	71CAO
C-5A		Glide Slope Receiver	71GAO
FB-111A	APQ-114	Modulator R/T MD-764	73JCO
FB-111A	APQ-114	Radar Control C-7487	73JFO

A cross verification of coefficients was performed on each of the 15 relationships developed using the 11 observations (Table 40) in the validation data base as shown in Appendix C to obtain the second sample of data. Table 41 gives a brief summary of some of the validation results using the cross verification of coefficients approach. The reader is referred to Volume II for a view of the "total picture" of these results including

coefficients, residuals, fitted values plots, residual plots and component plus residuals plots (for a few key dependent variables). Table 41 gives information on each dependent variable including the percent change in the coefficients from the original data base, the number of LRUs in the regression data base, the multiple correlation coefficient squared, R_y^2, and the F-value for both the original data and the second sample of data. Also included in Table 41 are the results obtained by viewing the component plus residual plots, the basic set of variables (i.e. those variables in each equation which must be in "best" fitting equation) for both cases and the results of the Cp-Search technique using the second sample of data. For example, for the dependent variable LSCTOT/OH, the percent change in all the coefficients in the equation is not "significant". There was an R_y^2 value of .88 for the equation obtained and .88 for the second sample of data. The initial F-value was 41.0 versus an F-value of 44.3. There is not a "significant" change in the component plus residuals plots. There were 10 variables initially in the basic set whereas with the validation data included, this value rose to 16 and the Cp-search technique agreed with the original results that there is no subset collection of the variables which fits the data "better" than that which was developed.

TABLE 41

VALIDATION RESULTS OF THE CROSS VERIFICATION OF COEFFICIENTS WITH A SECOND SAMPLE OF DATA

DEPENDENT VARIABLE	% CHANGE IN COEFFICIENTS	N1/N2	R_y^2	F-VALUE	COMPONENT PLUS RESIDUAL PLOT	BASIC SET OF VARIABLES	CP-SEARCH TECHNIQUE
MTBF	OK	120/131	.89/.87	32.1/31.7	OK	21/21	SAME
MTBMA	OK	120/131	.88/.86	29.3/29.7	OK	5/12	SAME
MMHTOT/OH	DUP/54%	119/130	.93/.92	61.9/65.5	OK	15/18	THIRD
MMHUNS/OH	OK	119/130	.90/.90	48.6/52.9	OK	7/8	SECOND
MMHSHOP/OH	DUP/53%	119/130	.90/.89	66.6/67.4	OK	12/11	SIXTH
LSCTOT/OH	OK	117/128	.88/.88	41.0/44.3	OK	10/16	SAME
LSCFLD/OH	OK	116/127	.88/.88	42.6/46.3	OK	9/8	SAME
NRTS	OK	116/127	.66/.66	15.4/16.5	OK	1/1	SAME
SRA	OK	108/119	.87/.86	46.3/46.8	OK	12/12	SAME
TRAIN/OH	OK	118/129	.85/.85	22.5/21.0	OK	7/9	SAME
MMHTOT/OH*	DUP/47%	119/130	.93/.92	62.4/65.7	OK	14/15	FIFTH
MMHSHOP/OH*	DUP/40%	119/130	.90/.90	69.6/71.8	OK	12/12	SECOND
LSCFLD/OH*	OK	116/127	.89/.89	50.5/54.8	OK	14/14	SECOND
MMHTOT/OH**	DUP/60%	119/130	.92/.92	66.9/70.3	OK	16/16	THIRD
MMHUNS/OH**	OK	119/130	.90/.89	50.7/54.9	OK	7/7	SECOND

* NRTS is used as an independent variable.
** Results of Cp-search technique.

The results of this validation exercise were quite encouraging to say the least. Of the 15 equations developed for the ALPOS model there were only 5 equations (three involving MMHTOT/OH and two involving MMHSHOP/OH) where the coefficient of only one variable (DUP in each case, where DUP is the unit price minus its d-statistic squared) changed by an average of only about 50%. The three equations involving MMHTOT/OH were those developed without NRTS as an independent variable, with NRTS as an independent variable and the results of the Cp-search technique to find the second "best" equation for MMHTOT/OH. If there is a coefficient in the MMHTOT/OH equation (e.g. DUP) which changed and the Cp-search technique dictated that this variable was significant enough to stay in the second "best" equation, then it is expected that the coefficient of that variable should also change by a comparable amount. The two equations involving MMHSHOP/OH were those with and without NRTS as an independent variable. It should be noted that in each of these 5 cases where the coefficient of DUP changed by about 50%, the variable DUP was among the three least influential variables in the 5 equations developed. In the cases where the percent change in the coefficient was OK, there were only two equations with only one coefficient in each case which changed by about 30%, but in most of the remaining equations the percent change was far below 20% in each coefficient of each equation developed. It should be noted here that each of the coefficients could have changed by well over 100%. Moreover, the sign of each coefficient could also have changed (i.e. from a positive coefficient to a negative coefficient and vice versa). In these extreme cases, where the stability of the equation is questionable, there would have been cause to re-examine the validation data, the regression analysis data, and the estimating relationships.

The multiple correlation coefficient squared fell only slightly in each case (as was expected since the validation data was not used to develop the relationships) and the F-value was increased in all but one case (MTBF). There were no major discrepancies in the component plus residuals plots for all 15 equations. The basic set of variables was about the same with an increase in some cases for the second sample of data. The results of the Cp-search technique were the same in 6 of the relationships. In 4 of the relationships the Cp-search technique indicated that the equations developed were the second "best" relationships, but in all cases the residual mean square (a measure of the error of prediction) was smallest for the equations developed. Volume II contains a more detailed discussion of the statistical approach used for validation and all computer printouts of the LLSCFP verifying these statistical results.

Indeed, these results are extremely encouraging. The results are so good, in fact, that it would probably be difficult to duplicate the agreement in coefficients in other validation investigations. It would be appropriate, however, to increse the validation sample size to perform a more thorough investigation in order to further demonstrate how well the ALPOS estimating relationships model the "real world".

SECTION VIII

FEASIBILITY OF FURTHER MODEL ENHANCEMENTS

The ALPOS model, at its present stage of development, provides the user with a basic set of parametric relationships and other techniques for estimating downstream avionics support costs using limited input data. When compared to some other LCC/LSC models, the ALPOS development costs have been modest. In light of this and a number of other factors, however, ALPOS can be viewed as representing a demonstration prototype, pointing to future enhancements as a means of increasing the utility of the model. These factors include the availability of logistics data from a new data system, the update of the model's data base with design characteristics of avionics in newly fielded systems and the desirability of incorporating advanced methods of measuring the impact of BIT, maintenance levels and circuit technologies on support costs.

New Developments

LRU/SRU Model-IROS Enhancement

The design of an improved data system to provide visibility and management of component support costs is now underway in AFLC (PMD L-Y 7049(2)). This effort is in support of Management by Objective (MBO) 9-2 (II) issued by the Deputy Secretary of Defense "to expand weapon system O&S cost systems to obtain detailed data on weapon system subsystem and replaceable component maintenance costs". The basic approach to fulfilling this objective is to enhance the IROS (KO51) Logistic Support Cost Ranking data system which was used as a primary source of LSC data for ALPOS. The term "LRU/SRU model" is used to refer to product of the IROS enhancement.

It appears that newly automated interfaces with various Air Force data systems will provide improved base level labor and consumable costs as well as improved tracking of depot transactions which are NSN oriented, with base level WUC related transactions. This should greatly reduce the number of depot transactions that are believed to be lost in the present KO51 system. Other improvements will be in the areas of providing a better source of unit cost data and providing maintenance manhours and other factors that are actually being used to determine the elements of the total LSC. Table 42 summarizes the cost structure of the LRU/SRU model.

Following a successful demonstration by AFLC of the feasibility of developing this model, the formalized data system is now being automated. It is anticipated that the system will be operational by February, 1981. Undoubtedly, this system will become the standard source of Air Force LSC data at the subsystem, LRU and SRU level. Its existence alone will probably necessitate a

TABLE 42

PLANNED LRU/SRU MODEL COST ELEMENTS

Component related costs (by Work Unit Codes)

Base level maintenance costs.

"On" and "off" equipment labor.

Consumable material.

Maintenance overhead.

Material management overhead.

Supply and traffic management support.

Depot maintenance costs.

Repair of exchangeables.

Replacement of condemned exchangeables.

Depot "on" aircraft maintenance.

Repair of engines.

Second destination transportation costs.

Exchangeables.

Consumables.

MDS related costs.

Support general labor.

Modifications (TCTOs).

Labor.

Material.

Overhead.

Second destination transportation.

review of the need for updating any techniques or models that require historical LSC data to establish "baselines" on new systems or to develop estimating relationships.

Availability of Data for Advanced Avionics Systems

By the time LSC data is available from the LRU/SRU model, it is expected that a significant number of F-16s will be fully operational. Over 150 F-16s are scheduled to be in the Air Force inventory by the end of 1980, whereas only a few are operating as of this writing. The navigation and fire control systems in this aircraft generally represent a higher level of technology than is currently in the data base. It would be desirable, therefore, to include LRUs from these systems in the data base for the development of any new estimating relationships.

The majority of the B-52 LRUs now in the data base are representative of older technologies. Many of these systems will be replaced by the Offensive Avionics System (OAS) improvements to the G and H models. With initial retrofit now scheduled for mid-1981, any update of the ALPOS model should include a review of the availability of LSC data for LRUs from these systems.

Improved Modeling Techniques

Any future enhancement effort should involve, as the initial task, a study of alternative ways of modeling the effect of some of the parameters on downstream costs. The need for these new approaches have been indicated primarily by the difficulty in obtaining data for certain parameters. Also, it has not been possible to further pursue some lines of investigation into areas that would have exceeded the scope of this effort.

As pointed out in Section IV, one of these areas involves the impact of BIT. Any enhancement effort to the model requires a review of the recent findings of various Air Force studies which have addressed the issue of standardized BIT/FIT figures of merit. The application of those figures of merit to improving the measures of BIT now currently in the data base would most assuredly benefit any additional modeling effort.

Another area of investigation should address the impact of VHSI on downstream support costs and how the effect of VHSI should be modeled. This could possibly involve the development of an algorithm which uses the result of an estimating relationship as a "baseline" from which a change in cost can be estimated.

The development of complexity factors (other than components density) for use as independent variables in the relationships has not yet been explored. This is another area where the relationships developed through regression analysis could be enhanced. Some of the large residual differences between observed and fitted values which appeared in the analysis for a few of the data sets could possibly be resolved by the

introduction of these factors. To facilitate this possible enhancement, the number of IC's and SRU's in each LRU has been already added to the data base.

Regression Analysis

As new and improved data become available, it will surely be desirable to determine the impact these new data elements have on the estimated coefficients of the relationships obtained. The stability of the obtained equation's coefficients can be determined by the technique of cross verification of coefficients (see Volume II). Cross verification of coefficients with a second sample of data provides a rigorous test of the data, the model and the fitted coefficients. Component-plus-residual plots (see Volume II) of the second sample of data (where residuals are calculated using the initial coefficients) may point out observations which may indicate that other forms of curvature are needed. Based on the results, the user may desire to update those relationships which have significantly different coefficients.

The user may also desire to develop relationships for parameters not currently in the model, such as base level consumable material costs or total repair cost of depot exchangeables. From the perspective of the AFAL being the principle user of the model, a question arises concerning the means for accomplishing model enhancements, including regression analysis. Is it necessary to perform model enhancements through contractual efforts or can this be accomplished using Air Force personnel? The AFAL has already demonstrated that it can access a number of operational routines for regression analysis including the Statistical Package for the Social Sciences (SPSS), Biomedical Computer Programs (BMD), OMNITAB (National Bureau of Standards) and an abbreviated version of the LLSCFP. The proper use of any of these sophisticated routines, however, does not involve a simple mechanized procedure, but does require a great deal of judgement and skill on the part of the analyst. Therefore, a prerequisite for the AFAL to perform this analysis in-house would be the availability of personnel knowledgeable in the interpretation of various interelated goodness of fit measures and plots other than R_y^2 and F statistics. This is especially true in the use of the LLSCFP as shown in Volume II.

Performing regression analysis in-house would benefit the AFAL since the user would have first hand knowledge of the impacts of updates and changes in the data base on the regression results. The AFAL may wish at some point to include proprietary information in the data base that is not generally available to contractors. Also, the AFAL could directly participate in certain judgements made during the analysis process. These judgements could involve the classification of various data sets as outliers and the determination of the independent variables which remain in the final form of the relationships.

Conclusions

Further enhancement of the ALPOS model is necessary to take advantage of the benefits offered by an improved LSC data system while at the same time including advanced technology systems in the data base. Because this data will not be available until 1981, the intervening period could be used to conduct a thorough evaluation of ALPOS and, based on the results of this evaluation, an investigation of improved modeling techniques. The results of a particular area of investigation could possibly be incorporated in the ALPOS model without the need for performing additional regressions, or the results could be an influential factor in determining the variables to be included in the updated relationships when the improved LSC data is available.

SECTION IX

SUMMARY AND RECOMMENDATIONS

This study has resulted in a predictive computer model which incorporates a number of PERs, CERs, and algorithms for estimating downstream support cost of alternative avionic designs while in the conceptual phase. The study has demonstrated that sophisticated regression analysis techniques can be successfully applied to link a broad spectrum of avionics design characteristics to the support cost/parameters associated with a large number of LRUs aboard a diverse sample of aircraft. As such, the usefulness of existing Air Force data systems has been extended and a greater significance can be attached to the importance of developing new and/or improved data systems and estimating data bases. As a result of the study, the Air Force Avionics Laboratory has been provided with the only generalized analytical tool, which is directly relatable to Air Force data systems, for early assessment of how avionics LRU characteristics impact support costs.

Five key recommendations concerning further development of ALPOS in the immediate future and long term have resulted from this study. They are:

Immediate Future

1. Perform an extensive developmental testing and evaluation. Efforts to date have not benefited from the information feedback of results obtained when the model is exercised in "real world" applications. The model needs to be evaluated in the actual decision making environment present during the typical conceptual/early design stages. This evaluation would demonstrate the strengths of the model as well as indicate any weaknesses regarding:

   a. Input data available vs. input data accepted by the model.

   b. Required outputs for decision making vs. outputs generated by the model.

   c. Results obtained from the model for a known "baseline" system vs. the results expected to be obtained for an alternative design.

   d. Actual results obtained from the model for the alternative vs. both the baseline results and expected results obtained in c.

The evaluation will emphasize the need to incorporate some of the improvements suggested in Section VIII in addition to new considerations. Following testing, the lessons learned can and should be applied to model enhancements.

2. Perform a cross verification of regression coefficients with those now in the model using the additional data assembled for the evaluation. It is realized that some of the dependent variable data (e.g. LSC/OH, MMH/OH, MTBMA, etc.) will not be from actual field results (as was used in model development), but will be from engineering estimates.

   An analysis of these results would give additional insight to the functional forms of the estimating relationships to be used in future regression analyses.

3. Determine the availability of other design characteristics which should be considered for use in a future version of the model by reviewing the data collected for the evaluation (which is representative of that available during the typical conceptual phase).

   a. For example, if an estimate of the number of ICs can be expected to accompany the total components count estimate, this could be included as a parameter in the model. This is an interesting model parameter for study from the viewpoint that with more advanced avionics, the percentage of ICs to total components count will tend to increase; however, the absolute number of ICs in an LRU, after increasing during the past years, may tend to decrease in the 1980's as a result of greater usage of LSI, and the introduction of VHSI.

   b. Where a reliable estimate of the number of SRUs in an LRU is available, this can be used in the model. In past years, high LRU complexity has been characterized by a large number of SRUs. With greater circuit integration, however, functions of equivalent complexity may be performed by a much smaller number of SRUs implying reduced support costs.

   c. Using the above parameters, a complexity factor can be formulated. The application of this factor can be as an independent variable in a regression analysis, or it can be used in an algorithm to establish a "delta" in support costs or other parameters from some baseline.

   d. Another aspect of data review should be in the BIT/FIT area. The statement of the design objective for BIT/FIT effectiveness of each LRU alternative should be considered. Design specifications such as isolating 95%

of the malfunctions down to one LRU, would not differ for different alternatives whereas objectives for each alternative which exceed the specification should affect model results differently. Also the design objective should be compared with the actual results to be expected in the field (which is the type of factor used in the Phase I relationships) as well as "standardized" figures of merit referred to in Section VIII. This review will give additional insight to the type of BIT/FIT factor(s) that can be used as a parameter in future regression analyses.

4. Develop a computer routine within ALPOS to perform sensitivity analyses for all the independent variables. For the percentage LRUs not repairable this station (NRTS), this routine would be used to determine the impact of varying NRTS values on field LSC costs, depot costs and initial spares costs. This routine would incorporate the relationships already available in the model and would serve as a basis for a preliminary investigation of how ALPOS could be used to evaluate the impacts of alternative maintenance philosophies such as 2, 2-1/2 or 3 level maintenance.

Recommendations - Long Term

1. Periodically update the data base and perform additional regression analyses to minimize obsolescence. This aspect was discussed in Section VIII. There is a corollary investigation, however, that should be taken to facilitate this update:

   a. Determine a method of automatically extracting selected data from the AFLC computer files for the LRU/SRU model outputs. This method would eliminate the need for time-consuming manual transcription of large amounts of information from microfiche and the human errors that are associated with such a task.

   b. Establish a support cost estimating data base. This would contain support cost as well as related design information for LRUs. Selected data from the LRU/SRU model would be automatically written into some elements of the data base using the method determined in (a.) while the associated design information would be entered via remote on-line terminals. The ALPOS data base now assembled would serve as the nucleus for this larger collection of information.

c. Investigate available file management or data base management systems that could be used to assist in updates and queries of the data base. This system should be capable of retrieving specific data sets and reformatting the data so that it can be directly input to a regression analysis program such as the LLSCFP. This would eliminate the need for transcribing reduced data to computer coding forms and the punching of input data cards.

These recommendations are being made to increase the responsiveness of the model to prediction requirements foreseen for avionics designs and support environments in the mid and late 1980's. As pointed out in the recent Report On Logistics Planning and Development for OASD (MRA&L)(18), parametric estimating of O&S costs made during early program phases when little data is available will be one of major decision making tools for future acquisitions.

A number of trends are apparent in the 1980's that will effect acquisitions and mandate a continual need for review and update of ALPOS. In the area of avionics design the trend is toward the use of digital electronics with the incorporation of BIT and FIT in complex integrated circuits where a single chip may assume the function of today's SRU or LRU. In the area of support philosophy, there is a trend towards increased depot repair, with automatic test equipment being heavily relied upon at all levels of maintenance. In the area of personnel training, the trend is towards less formal technical courses, with more reliance on job performance aids (JPAs) and on-the-job training.

These are but a few of the trends which can be expected to contribute to a decrease in avionics support costs. No abatement can be expected, however, in the pressures to better control and, thereby, further reduce support costs. In this environment, greater emphasis will be placed on the use of predictive models as a primary tool for exercising control.

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APPENDIX A

SUMMARY OF DATA ELEMENTS AND SOURCES

DATA ELEMENT (NAME IN MODEL)	DEFINITION/UNITS	SOURCE	REMARKS
1. Unit Price (UP)	$/LRU	a) IROS-PN8L b) Federal Stock List	a) Year of last buy determined from Federal Stock List and adjusted to 1976 $'s using Wholesale Price Index factors. PN8L updates usually lag microfiche issue date by one year.
2. Volume (V)	in^3	a) "-2" T.O. or similar T.O. b) Nav. Equip. Handbooks c) Equip. Data Sheets - Tech at ALC d) Actual measurements performed during Base visits.	a) Some "-2" T.O. at others at Base AMS/CRS. b) Handbooks published by ARINC Research. c) Data Sheets available only on older LRUs.
3. Weight (W)	Lbs.	a) "-2" T.O. or similar T.O. b) Nav. Equip. Handbooks/Data Sheets	a) Weight in PN8L is shipping weight, and was not used.

APPENDIX A (Continued)

SUMMARY OF DATA ELEMENTS AND SOURCES

DATA ELEMENT (NAME IN MODEL)	DEFINITION/UNITS	SOURCE	REMARKS
4. Compo-nents Count (CC)	No. Electrical Components (excludes screws, mechanical structure, con-nectors, etc.)	a) IPB in "-4" T.O. or similar T.O.	a) Some "-4" T.O.s at , others at Base AMS/CRS. b) Must estimate counts for potted components and "black boxes".
5. Compo-nents Density (CD)	Component Count per unit volume	a) Derived from #4 and #2.	
6. Power Dissipa-tion (PD)	Input power less output power (watts)	a) Derived from input power and/or output power shown in "-2" T.O. b) Technicians at ALCs from reference to various specifica-tions.	a) See text of Final Report Section 4 for assumptions and methcdology.

APPENDIX A (Continued)

SUMMARY OF DATA ELEMENTS AND SOURCES

DATA ELEMENT (NAME IN MODEL)	DEFINITION/UNITS	SOURCE	REMARKS
7. Component Type (FDI) (FAN) (FEM) (FPS) (FXR)	Percentage digital, analog, electro-mechanical, power supply and transmitter. a) Percentage digital b) Percentage analog c) Percentage electro-mechanical d) Percentage P.S. e) Percentage XMTR	a) IPB in "-4" T.O.	a) See text of Final Report Section 4 for assumptions and methodology.
8. Percentage Solid State (FSS)	Percentage of components that are solid state	a) IPB in "-4"T.O.	a) See text of Final Report Section 4 for assumptions and methodology.

APPENDIX A (Continued)

SUMMARY OF DATA ELEMENTS AND SOURCES

DATA ELEMENT (NAME IN MODEL)	DEFINITION/UNITS	SOURCE	REMARKS
9. Aircraft Type and Command	a) Fighter, Bomber, Cargo		a) Fighters: F4E, RF-4C, F-15A, F-111D - 100% TAC.
			b) Bombers: B-52G/H, FB-111A
	b) TAC, SAC, MAC		- 100% SAC.
			c) Cargo: C-130E, C-5A - 100% MAC. KC-135A - 100% SAC.
10. Utilization Factor (UF)	Estimate of Total Operating Hours per Flying hour	a) Item Managers b) Visit to Bases c) Contacts with Field Engineers	a) Avonics assumed to be operating during pre-flight and post-flight aircraft check-outs.
11. BIT/FIT Mechanization (BF)	% failures detected by BIT/FIT	a) "27-LOG" b) Computed from "5-LOG"	a) Taken from "% failed auto test" How Mal code.

APPENDIX A (Continued)

SUMMARY OF DATA ELEMENTS AND SOURCES

DATA ELEMENT (NAME IN MODEL)	DEFINITION/UNITS	SOURCE	REMARKS
12. Flying Hours (FH)		a) "6-LOG"	a) Used to normalize LSC and MMH data on a per flying hour basis or on a per operating hour basis when the utilization factor is applied.
13. Logistic Support Costs	Annual $'s	a) IROS PN3L and PN4L	a) $TOTAL = $FIELD + $DEPOT + $PACK & SHIP + $COND The total of four (4) quarters of cost data was used.
14. Standard Technological Repair Center Cost	Average Depot Repair Cost ($) per LRU	a) IROS - PN8L	
15. Spares Costs	Annual $'s	a) Calculated from an expected backorder routine using predicted MTBMA and NRTS	a) See text of Final Report, Section 6.

APPENDIX A (Continued)

SUMMARY OF DATA ELEMENTS AND SOURCES

DATA ELEMENT (NAME IN MODEL)	DEFINITION/UNITS	SOURCE	REMARKS
16. Support Equip-ment Costs	Annual $'s	a) Calculated from a relationship using unit price and number of LRUs procurred.	a) See text of Final Report, Section 6.
17. Training Costs	Annual $'s	a) VAMOSC/OSCER	a) See text of Final Report concerning allocations to the LRU level.
18. MTBF	Hours	a) "6-LOG" (shows mean flight hours between failures)	a) The average of two six-month periods was used. b) The model predicts mean <u>operating hours</u> between failures.
19. MTBMA	Hours	a) "6-LOG" (shows mean flight hours between maintenance actions)	a) The average of two six-month periods was used. b) The model predicts mean <u>operating hours</u> between maintenance actions.

APPENDIX A (Continued)

SUMMARY OF DATA ELEMENTS AND SOURCES

DATA ELEMENT (NAME IN MODEL)	DEFINITION/UNITS	SOURCE	REMARKS
20. MMH	Hours	a) "6-LOG"	a) TOTAL MMH = SCHEDULED MMH + UN-SCHEDULED MMH + SHOP MMH The total of 2 six-month periods of data was used.
21. QPA		a) IROS-PN8L	a) Used as a multiplicative factor with operating hours.
22. % NRTS		a) "6-LOG"	

NOTE: Phase I data:
"6-LOG" - 6 months end 9/76 and 6 months end 3/77 IROS - 12 months end 3/77
"27-LOG" - 12 months end 7/77 VAMOSC - 12 months end 12/76

Phase II data:
"6-LOG" - 6 months end 12/77 and 6 months end 6/78 IROS - 12 months end 6/78

APPENDIX B

ALPOS

Multiple Regression Analysis Data

Used in Phase II

-Directory-

No.	WUC	MDS	A/N	NOUN	NSN
1.	71B20	F4E	ASN46A	Amplifier, Computer	6605008365333
2.	71LB0	F4E	ASQ19	Receiver-Transmitter	5826000824288
3.	71H60	F4E	ASN63	Platform, Gyro Stabilizer	6605009458168
4.	71PK0	RF4C	ASQ88	Receiver-Transmitter	5895000178935
5.	71PB0	RF4C	ASQ88	AMP. P.S. Rcvr	5895007554528
6.	71710	RF4C	ASN55	P.S. Leveling Amplifier	6615009099801
7.	724G0	RF4C	ASN159	Power Supply	5841009218453
8.	71G50	RF4C	ASN56	Navigational Computer	6605009992278
9.	71FA0	F15A	ASN108	AMP. Elec Control	6610001491134
10.	71FB0	F15A	ASN108	Gyroscope, Displacement	6615003036728
11.	71CA0	F15A		Receiver	5826002796334
12.	71DA0	F15A		Receiver-Transmitter	5826010215980
13.	51EA0	F15A	ASK6	Computer, Air Data	6610010042737
14.	52AA0	F15A	ASW38	Computer, Flight Control	6615010154794
15.	52AB0	F15A	ASW38	Computer, Flight Control	6615001377502
16.	63BD0	F15A		Control Panel, Int. Nav.	5895003278775
17.	71AE0	F15A	ASN109	Inertial Measurement Unit	6605001490757
18.	74JA0	F15A	OD60	Indicator, Mult, Air Nav.	6605010101472
19.	74JC0	F15A	OD60	Processor, Signal Data	6610001388216
20.	52GA1	F106		Amplifier, Interface	1270001489018
21.	71ZA0	F111D	ARN118	Receiver-Transmitter	5826010121938
22.	71ZB0	F111D	ARN118	Digital/Analog Converter	5826010124864
23.	71ZC0	F111D	ARN118	Control	5826010121919
24.	73EG0	F111D	AYK6	Computer, General Purpose	6605004488984
25.	73EP0	F111D		Converter, Multiplexer	6605045000793
26.	73HA0	F111D	AJN16	Stabilizer Platform	6605002564427
27.	73HC0	F111D	AJN16	Navigation Computer Unit	6605005604427
28.	73NA0	F111D	AYN4	Indicator, Horizontal Display	6605001669438

No.	WUC	MDS	A/N	NOUN	NSN
29.	73QB0	F111D	APN189	Electronic Unit, Radar	5841002601779
30.	73SC0	F111D		Indicator, Digital Display	6605004714233
31.	73KB0	F111D	APQ128	Antenna, Receiver	5841004045832
32.	73KE0	F111D	APQ128	Amplifier, Power Supply	5841009249067
33.	73KF0	F111D	APQ128	Synchronizer, Transmitter	5841001107082
34.	73KK0	F111D	APQ128	Computer, Terrain Follow	5841002886271
35.	75930	F4E		Weapons Release Control	1095000053688BF
36.	74BD0	F4E	APQ120	Computer	1430001060942BF
37.	74BF0	F4E	APQ120	Transmitter	1430000037259BF
38.	74810	F4E	ASG26	Gyroscope, Lead Computer	1270004767945
39.	76A10	RF4C	APR25	Analyzer, Pulse	5865001605036EW
40.	76GA0	RF4C	ALR46	Signal Processor	5865003605362EW
41.	74FF0	F15A	APG63	Processor	5841005111146
42.	74FA0	F15A	APG63	Transmitter	5841010070312
43.	74FH0	F15A	APG63	Power Supply	5841001387954
44.	74FU0	F15A	APG63	Antenna	5841003939349
45.	73CR0	F4E	ASQ153	Laser Control Electronic Pods	1270003495626
46.	73CG0	F4E	ASQ153	Two Axis Gimbal Assy. Pods	1270003495870
47.	65BH0	F15A		Processor, Radar Tgt. Data	5895001487136
48.	74FC0	F15A	APG63	Receiver, Radar	5841002791492
49.	74FJ0	F15A	APG63	Oscillator, Radio Frequency	5841005994156
50.	74FK0	F15A	APG63	Radar Set Control	5841001255114
51.	74FQ0	F15A	APG63	Processor, Radar Data	5841010250257
52.	74KA0	F15A	AVQ20	Display Unit, Head-Up	6605001377279
53.	74KC0	F15A	AVQ20	Processor, Signal Data	6605010405948
54.	74CA0	F4E	APQ120	Indicator Control Unit	1430000144433
55.	74CB0	F4E	APQ120	Indicator, Pilot	1430000434414
56.	74CC0	F4E	APQ120	Indicator, Pilot System Observer	1430010033978
57.	74FA1	F106		Input-Output Unit	1270001739679
58.	74EB0	F15A		Lead Computing Gyro	1270010087862
59.	73PH0	F111D	APQ130	Power Supply, Low Voltage	5841000062926
60.	73PB0	F111D	APQ130	Processor, Electronic	5841010347131
61.	73PD0	F111D	APQ130	Radar Transmitter	5841000056851
62.	73PF0	F111D	APQ130	Signal Data Converter	5841010330166

No.	WUC	MDS	A/N	NOUN	NSN
63.	73PM0	F111D	APQ130	Reference Signal Generator	5841004350133
64.	71NA0	F4E	ASQ198	Receiver-Transmitter	5895008782018
65.	71QU0	RF4C	ASQ88	Receiver-Transmitter	5895008782018
66.	63AA0	F15A	ARC109	Receiver-Transmitter	5821001351701
67.	65AA0	F15A	APX101	Receiver-Transmitter	5821001351701
68.	63AG0	F15A	ARC109	Radio Receiver	5821004341533
69.	63BC0	F15A		Control Panel Integrated Comm	5895003409608
70.	63BF0	F15A		Control panel IFF	5895003409619
71.	71ABE	B52H	ARN67	Receiver	5826007210168
72.	71ADA	B52H	ARN21	Receiver-Transmitter	5826007660817
73.	73DBA	B52H	APN89	Receiver-Transmitter	5841008124771
74.	71ACC	B52H	ARN32	Receiver	5826006269874
75.	73CBQ	B52H	ASQ38	Amplifier	1280005033613
76.	73CEN	B52H	ASQ38	Computer AZ & EL	1280001720746
77.	73CFK	B52H	ASQ38	Receiver-Transmitter	1280005063405
78.	73DAH	B52H	APN89	Amplifier, Electronic Cont.	5841007992858
79.	73EBA	B52H	MD1	AMP Astrotrack Servo	6605006752213
80.	73EBF	B52H	MD1	Signal Amplifier	6605006582564
81.	71CA0	FB111A	ARN84	Receiver-Transmitter	5826002266029
82.	73EG0	FB111A		Computer, General Purpose	6605004488984BJ
83.	73HC0	FB111A	AJN16	Navigation Computer Unit	6605003601494
84.	73LA0	FB111A	APN185	Electronic Unit	5841004335542
85.	77EC0	B52H	AAQ6	FLIR Signal Processor	1280001596191
86.	77EE0	B52H	AAQ6	FLIR Turret Drive	3010007824607AY
87.	77DCA	B52H	AVQ22	STV Camera Electronics	1280001866298
88.	77DB0	B52H	ASQ131	STV Turret Drive	3010007824607AY
89.	76AEA	B52H	ALQ117	Transmitter	5865000034569
90.	73KA0	FB111A	APQ134	Computer, Terrain Follow	5841002507374
91.	63BAA	B52H	ARC34	Receiver-Transmitter	5821005050945
92.	63CAA	B52H	ARC34	Receiver-Transmitter	5821005050945
93.	65BAA	B52H	APX64	Receiver-Transmitter	5895000894522
94.	61BBA	B52H	ARC58	Receiver	5821009912690
95.	61AA0	FB111A	ARC123	Receiver-Transmitter	5821008423483
96.	61AB0	FB111A	ARC123	Amplifier, Power Supply	5821008423471
97.	61AC0	FB111A	ARC123	Control	5821008423479
98.	72AA0	FB111A	APX78	Control, Radio Transponder	5895001351680
99.	72AC0	FB111A	APX78	Receiver-Transmitter	5895001351681
100.	71CA0	KC135A	ARN21	Receiver-Transmitter	5826008975519
101.	72EAA	KC135A	APN81	Receiver-Transmitter	5841003032631

No.	WUC	MDS	A/N	NOUN	NSN
102.	73ECA	KC135A	APN81	Amplifier, Electronic Cont.	5841006009319
103.	72BP0	C5A		Measurement Unit IMU	6605000984891LH
104.	71JA0	C5A		Receiver, VHF, NAV	5826000613080
105.	71LA0	C5A		Receiver-Transmitter	5826004360760
106.	73DN0	C5A		Processor Data	5841004809752LH
107.	72AC0	C5A		P.S. Thermal Control	6605000928799LH
108.	71716	C130E	ARN67	Receiver	5826007210168
109.	7131D	C130E	ARN21	Receiver-Transmitter	5826005430795
110.	72RF0	C130E	APN59	Power Supply	5841009272431
111.	72RB0	C130E	APN59	Amplifier	5841008512604
112.	71JCE	C5A		Control panel VHF NAV	5821000691774
113.	72AE0	C5A		Computer, Primary IDNE	7021000928782
114.	72CC0	C5A		Computer, Analog/ Digital	6605000984877
115.	71ZA0	C130E	ARN118	Receiver-Transmitter	5826010121938
116.	71ZB0	C130E	ARN118	Digital/Analog Converter	5826010124864
117.	71ZD0	C130E	ARN118	Control Unit	5826010121919
118.	65BAA	KC135A	APX64	Receiver-Transmitter	5895000894522
119.	63AFO	KC135A	ARC34	Receiver-Transmitter	5821009306298
120.	63AA0	C5A	ARC109	Receiver-Transmitter	5821001957722
121.	63121	C130E	ARC34	Receiver-Transmitter	5821005050945
122.	63AAA	C130E	ARC164	Receiver-Transmitter	5821001387991
123.	55ALO	C5A		Central Multiplex Adapter	4920004896504
124.	55AVO	C5A		Computer, Digital, Madar	4920001464968
125.	61AA0	C5A		Exciter, RCVR, HF/55B	5821006173199
126.	61AEO	C5A		Panel, Control, HF/55B	5821001029258
127.	62AA0	C5A		Transceiver, VHF Comm	5821000704475
128.	64211	C130E	AIC18	Intercom Set	5831009523454

A L P O S

Multiple Regression Analysis Data

Used in Phase II

-Key to Columnar Headings-

1. FIGHTER = Fighter indicator variable (1 indicates fighter aircraft)
2. BOMBER = Bomber indicator variable (1 indicates Bomber aircraft)
3. CARGO = Cargo indicator variable (1 indicates Cargo aircraft)
4. NAV = Navigational indicator variable (1 indicates navigational avionics)
5. SENS = Sensory indicator variable (1 indicates sensory avionics)
6. COMM = Communications indicator variable (1 indicates comm avionics)
7. UPRICE = Unit Price
8. VOLUME = Volume (in^3)
9. WEIGHT = Weight (lbs)
10. CCOUNT = Component Count
11. DIGITAL = Percentage Digital Components
12. ANALOG = Percentage Analog Components
13. EM = Percentage Electro-Mechanical Components
14. PS = Percentage Power Supply Components
15. XMTR = Percentage Transmitter Components
16. SS = Percentage Solid State Components
17. POWDIS = Power Dissipation (watts)
18. UFACT = Utilization Factor (Operating hours/flying hour)
19. BITFIT = Percentage Failures Detected by Automatic Test
20. IC = Number of Integrated Circuits
21. SRU = Number of SRU's in the LRU
22. MTBF = Mean Time (flight hours) Between Failures
23. MTBMA = Mean Time (flight hours) Between Maintenance Actions
24. MMHSCH = Maintenance Manhours - Scheduled (Organizational)
25. MMHUNS = Maintenance Manhours - Unscheduled (Organizational)
26. MMHSHO = Maintenance Manhours - Shop (Intermediate)
27. LSCFLD = Logistic Support Cost - Field
28. LSCSRC = Logistic Support Cost - Special Repair Center (Depot)
29. LSCPAC = Logistic Support Cost - Packaging and Transportation
30. LSCCON = Logistic Support Cost - Condemnation Replenishments
31. NRTS = Percentage LRU's Not Repairable This Station
32. FLYHRS = Flying Hours (FH)
33. COND = Percentage Condemned LRU's
34. SRA = Specialized Repair Activity (Depot) Costs
35. QPA = Quantity per Assembly
36. TRAIN = Training Cost
37. FHTRAIN = Flying hours used to normalize training cost

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	OPA	TRAIN	FHTRAIN		
1 71B20	1.	0.	0.	1.	0.	0.			
	13721.	443.	17.70	410.	0.0	86.0	14.0	0.0	0.0
	86.0	200.	2.30	0.0	0.	9.			
	106.	71.	115.	5525.	6234.	172027.	33294.	2594.	0.
	13.0	152328.	0.0	0.	1.	54282.	148201.		
2 71L80	1.	0.	0.	1.	0.	0.			
	6681.	1444.	40.00	491.	0.0	75.0	0.0	0.0	25.0
	27.0	212.	2.30	0.0	0.	16.			
	118.	70.	12.	5730.	12208.	266701.	25967.	1794.	0.
	27.0	152328.	0.0	696.	1.	76033.	148201.		
3 71H60	1.	0.	0.	1.	0.	0.			
	36913.	1676.	30.60	78.	0.0	24.0	76.0	0.0	0.0
	24.0	820.	2.30	0.0	0.	4.			
	0.	0.	103.	7862.	12206.	0.	0.	0.	0.
	16.0	152329.	0.0	3488.	1.	509503.	148201.		
4 71PK0	1.	0.	0.	1.	0.	0.			
	8410.	1473.	40.00	689.	0.0	74.0	1.0	0.0	25.0
	95.8	77.	2.30	0.0	0.	13.			
	0.	0.	13.	3990.	5694.	122916.	90305.	6088.	0.
	11.0	85458.	0.0	756.	1.	44106.	67590.		
5 71P80	1.	0.	0.	1.	0.	0.			
	2241.	1276.	36.50	758.	0.0	86.0	14.0	0.0	0.0
	68.0	289.	2.30	0.0	0.	19.			
	292.	207.	27.	1473.	3676.	70726.	8401.	805.	0.
	6.0	85458.	0.0	470.	1.	17822.	67590.		
6 71710	1.	0.	0.	1.	0.	0.			
	840.	91.	4.00	12.	0.0	100.0	0.0	0.0	0.0
	100.0	20.	2.30	1.0	0.	5.			
	1843.	1096.	0.	303.	381.	10090.	601.	25.	0.
	9.0	85458.	0.0	191.	1.	2610.	67590.		
7 724G0	1.	0.	0.	1.	0.	0.			
	2055.	133.	1.25	84.	0.0	97.0	3.0	0.0	0.0
	97.0	87.	2.30	0.0	0.	1.			
	2023.	1539.	1.	207.	268.	5732.	1963.	27.	0.
	4.0	85458.	7.0	245.	1.	1980.	67590.		
8 71G50	1.	0.	0.	1.	0.	0.			
	23327.	584.	14.00	421.	0.0	89.0	11.0	0.0	0.0
	34.0	172.	2.30	13.0	0.	21.			
	99.	41.	0.	0.	0.	97351.	4098.	281.	0.
	4.0	85458.	0.0	0.	1.	0.	0.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
9 71FA0	1.	0.	0.	1.	0.	0.			
	17232.	142.	13.90	412.	49.0	49.0	2.0	0.0	0.0
	98.0	384.	2.30	19.0	259.	18.			
	678.	398.	2.	534.	2087.	34206.	22860.	480.	0.
	25.0	54934.	0.0	1000.	1.	699.	6056.		
10 71FB0	1.	0.	0.	1.	0.	0.			
	11908.	424.	13.90	61.	0.0	33.0	67.0	0.0	0.0
	33.0	175.	2.30	17.0	1.	1.			
	343.	251.	7.	990.	1336.	0.	0.	0.	0.
	10.0	54934.	0.0	2167.	1.	7205.	6056.		
11 71CA0	1.	0.	0.	1.	0.	0.			
	5176.	200.	6.50	150.	0.0	100.0	0.0	0.0	0.0
	100.0	20.	2.30	13.0	0.	9.			
	2113.	931.	2.	240.	376.	9912.	0.	0.	0.
	10.0	54934.	0.0	1500.	1.	140.	6056.		
12 71DA0	1.	0.	0.	1.	0.	0.			
	30145.	866.	29.80	32.	0.0	75.0	0.0	0.0	25.0
	93.0	70.	2.30	18.0	0.	11.			
	288.	177.	3.	1274.	3184.	42245.	95556.	468.	0.
	17.0	54934.	0.0	3556.	1.	5552.	6056.		
13 51EA0	1.	0.	0.	1.	0.	0.			
	15848.	642.	16.30	1031.	87.0	7.5	0.0	5.5	0.0
	100.0	191.	2.30	29.0	411.	14.			
	495.	187.	31.	1558.	3552.	59198.	21555.	190.	0.
	14.0	54934.	0.0	1584.	1.	1332.	6056.		
14 52AA0	1.	0.	0.	1.	0.	0.			
	15699.	608.	11.80	1443.	94.4	0.0	1.0	4.6	0.0
	100.0	206.	2.30	0.0	65.	7.			
	549.	276.	11.	1225.	3358.	69649.	47699.	594.	0.
	20.0	54934.	0.0	0.	1.	2064.	6056.		
15 52AB0	1.	0.	0.	1.	0.	0.			
	36015.	608.	11.80	1142.	100.0	0.0	0.0	0.0	0.0
	100.0	191.	2.30	44.0	125.	12.			
	670.	374.	16.	995.	3549.	62939.	64648.	351.	0.
	25.0	54934.	0.0	3600.	1.	1283.	6056.		
16 63BD0	1.	0.	0.	1.	0.	0.			
	2814.	78.	2.00	79.	0.0	100.0	0.0	0.0	0.0
	100.0	7.	2.30	0.0	7.	3.			
	1373.	639.	0.	205.	312.	0.	0.	0.	0.
	0.0	54934.	0.0	497.	1.	288.	6056.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
17 71AE0	1.	0.	0.	1.	0.	0.			
	192215.	1709.	40.00	3193.	85.7	7.1	1.5	5.7	0.0
	98.5	249.	2.30	41.0	948.	4.			
	111.	72.	3.	4225.	26171.	0.	0.	0.	0.
	0.0	54934.	0.0	0.	1.	0.	0.		
18 74JA0	1.	0.	0.	1.	0.	0.			
	29570.	8033.	21.50	260.	0.0	63.4	0.0	36.6	0.0
	98.7	75.	2.30	54.0	39.	16.			
	215.	114.	12.	2795.	8294.	122019.	302167.	1769.	0.
	29.0	54934.	0.0	3096.	1.	8373.	6056.		
19 74JC0	1.	0.	0.	1.	0.	0.			
	25830.	1906.	21.00	1824.	88.5	6.8	0.0	4.7	0.0
	100.0	1000.	2.30	0.0	469.	16.			
	513.	310.	11.	918.	2358.	42405.	9799.	71.	0.
	26.0	54934.	0.0	2580.	1.	1102.	6056.		
20 52GA1	1.	0.	0.	1.	0.	0.			
	9431.	295.	7.00	275.	47.0	47.0	6.0	0.0	0.0
	100.0	25.	3.10	5.6	63.	7.			
	73.	61.	90.	1652.	835.	71688.	0.	0.	0.
	2.0	33966.	0.0	450.	1.	2128.	33333.		
21 71ZA0	1.	0.	0.	1.	0.	0.			
	8027.	748.	26.50	2060.	75.0	0.0	0.0	0.0	25.0
	99.9	100.	2.30	16.0	354.	1.			
	433.	214.	6.	330.	119.	5657.	7692.	382.	0.
	0.0	15600.	0.0	650.	1.	3658.	14989.		
22 71ZB0	1.	0.	0.	1.	0.	0.			
	1538.	154.	5.00	669.	50.0	50.0	0.0	0.0	0.0
	100.0	25.	2.30	0.0	85.	1.			
	1950.	867.	0.	0.	0.	1077.	0.	0.	0.
	0.0	15600.	0.0	650.	1.	0.	0.		
23 71ZC0	1.	0.	0.	1.	0.	0.			
	516.	94.	2.00	94.	0.0	100.0	0.0	0.0	0.0
	100.0	10.	2.30	0.0	17.	1.			
	0.	0.	0.	0.	0.	1583.	747.	37.	0.
	0.0	15600.	0.0	80.	1.	0.	0.		
24 73EG0	1.	0.	0.	1.	0.	0.			
	65920.	1573.	47.40	3322.	93.0	7.0	0.0	0.0	0.0
	100.0	225.	2.30	1.0	1543.	21.			
	0.	0.	83.	4634.	3110.	69867.	121156.	1064.	0.
	7.0	15600.	0.0	4667.	2.	58489.	14989.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
25 73EP0	1.	0.	0.	1.	0.	0.			
	215330.	1495.	40.00	6016.	80.0	20.0	0.0	0.0	0.0
	100.0	460.	2.30	1.0	1928.	69.			
	35.	22.	23.	3467.	8815.	190668.	0.	0.	0.
	2.0	15600.	0.0	83964.	1.	28287.	14989.		
26 73HA0	1.	0.	0.	1.	0.	0.			
	340533.	3178.	70.00	2654.	26.1	59.8	14.1	0.0	0.0
	85.5	1560.	2.30	0.0	113.	47.			
	44.	32.	17.	3348.	12875.	307090.	120441.	1370.	0.
	10.0	15600.	0.0	8838.	1.	49769.	14989.		
27 73HC0	1.	0.	0.	1.	0.	0.			
	121411.	1027.	26.00	3027.	41.7	39.0	0.0	19.3	0.0
	100.0	120.	2.30	2.0	713.	22.			
	45.	33.	28.	2822.	2630.	101679.	0.	0.	0.
	4.0	15600.	0.0	3365.	1.	0.	0.		
28 73NA0	1.	0.	0.	1.	0.	0.			
	82663.	1186.	46.00	433.	0.0	20.0	80.0	0.0	0.0
	20.0	287.	2.30	1.0	0.	15.			
	0.	0.	0.	1453.	2137.	33523.	71870.	420.	0.
	8.0	15600.	0.0	14255.	1.	20503.	14989.		
29 73Q80	1.	0.	0.	1.	0.	0.			
	105551.	659.	20.00	602.	0.0	80.0	0.0	20.0	0.0
	100.0	128.	2.30	1.0	0.	11.			
	74.	48.	4.	1248.	2981.	160884.	0.	0.	0.
	6.0	15600.	0.0	3992.	1.	10124.	14989.		
30 73SC0	1.	0.	0.	1.	0.	0.			
	88084.	1048.	18.60	994.	90.0	10.0	0.0	0.0	0.0
	100.0	60.	2.30	0.0	611.	15.			
	123.	78.	14.	850.	574.	0.	0.	0.	0.
	18.0	15600.	0.0	9082.	1.	0.	0.		
31 73KB0	1.	0.	0.	1.	0.	0.			
	12764.	2785.	27.90	846.	0.0	100.0	0.0	0.0	0.0
	98.5	200.	2.30	0.0	0.	12.			
	0.	0.	2.	2525.	3991.	97434.	0.	0.	0.
	0.3	15600.	0.0	1485.	2.	13995.	14989.		
32 73KE0	1.	0.	0.	1.	0.	0.			
	38630.	713.	18.50	648.	0.0	0.0	8.2	91.8	0.0
	91.8	9.	2.30	0.0	0.	11.			
	272.	196.	25.	555.	1599.	31854.	0.	0.	0.
	0.0	15600.	0.0	0.	2.	3275.	14989.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER UPRICE SS MTBF NRTS	BOMBER VOLUME POWDIS MTBMA FLYHRS	CARGO WEIGHT UFACT MMHSCH COND	NAV CCOUNT BITFIT MMHUNS SRA	SENS DIGTAL IC MMHSHO QPA	COMM ANALOG SRU LSCFLD TRAIN	 EM LSCSRC FHTRAIN	 PS LSCPAC	 XTMR LSCCON
33 73KF0	1.	0.	0.	1.	0.	0.			
	5380.	826.	27.60	272.	0.0	97.2	2.8	0.0	0.0
	95.8	920.	2.30	2.0	0.	3.			
	130.	91.	7.	673.	773.	21558.	0.	0.	0.
	0.0	15600.	0.0	1256.	2.	5105.	14989.		
34 73KK0	1.	0.	0.	1.	0.	0.			
	2507.	622.	16.40	3164.	0.0	100.0	0.0	0.0	0.0
	100.0	100.	2.30	3.0	7.	14.			
	61.	51.	14.	1294.	3419.	74948.	7034.	182.	0.
	7.0	15600.	0.0	928.	2.	17143.	14989.		
35 75930	1.	0.	0.	0.	1.	0.			
	3015.	94.	4.00	108.	0.0	100.0	0.0	0.0	0.0
	100.0	7.	2.30	0.0	0.	2.			
	2545.	569.	0.	1442.	1490.	15022.	0.	0.	18167.
	0.0	152328.	2.0	207.	1.	5487.	148201.		
36 74BD0	1.	0.	0.	0.	1.	0.			
	10120.	1609.	43.70	1126.	0.0	61.0	39.0	0.0	0.0
	61.0	212.	2.30	0.0	2.	17.			
	84.	55.	489.	6676.	15473.	295635.	107964.	4374.	20511.
	5.0	152328.	0.0	0.	1.	102292.	148201.		
37 74BF0	1.	0.	0.	0.	1.	0.			
	15258.	1377.	78.50	399.	0.0	0.0	0.0	0.0	100.0
	98.0	900.	2.30	1.0	5.	5.			
	73.	51.	178.	7408.	9831.	228148.	36175.	3534.	0.
	25.0	152328.	0.0	815.	1.	69371.	148201.		
38 74810	1.	0.	0.	0.	1.	0.			
	6267.	577.	11.00	35.	0.0	0.0	100.0	0.0	0.0
	0.0	430.	2.30	5.0	0.	1.			
	926.	550.	11.	1023.	437.	26680.	45931.	1303.	0.
	93.0	152328.	0.0	739.	1.	15481.	148201.		
39 76A10	1.	0.	0.	0.	1.	0.			
	2652.	560.	15.00	911.	0.0	100.0	0.0	0.0	0.0
	100.0	335.	2.30	6.0	1.	10.			
	658.	166.	40.	1181.	1131.	68824.	3350.	219.	0.
	0.0	85458.	0.0	326.	1.	16382.	67590.		
40 76GA0	1.	0.	0.	0.	1.	0.			
	19274.	551.	25.00	1319.	100.0	0.0	0.0	0.0	0.0
	100.0	1300.	0.30	0.0	469.	11.			
	1327.	538.	0.	421.	267.	22705.	34726.	511.	0.
	42.0	85458.	0.0	0.	1.	10711.	67590.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
41 74FF0	1.	0.	0.	0.	1.	0.			
	220943.	2278.	41.00	7638.	100.0	0.0	0.0	0.0	0.0
	100.0	1300.	2.30	51.0	4625.	37.			
	135.	86.	36.	2784.	5177.	112056.	0.	0.	0.
	19.0	54934.	0.0	0.	1.	1143.	6056.		
42 74FA0	1.	0.	0.	0.	1.	0.			
	156000.	5330.	173.70	1558.	0.0	0.0	0.0	0.0	100.0
	99.0	270.	2.30	61.0	160.	14.			
	100.	59.	157.	5857.	15395.	314423.	10999.	5985.	0.
	15.0	54934.	0.0	211.	1.	5272.	6056.		
43 74FH0	1.	0.	0.	0.	1.	0.			
	42023.	1866.	35.00	932.	0.0	0.0	0.0	100.0	0.0
	100.0	1620.	2.30	65.0	13.	5.			
	156.	77.	101.	3179.	6558.	157363.	11998.	342.	0.
	14.0	54934.	0.0	1525.	1.	2599.	6056.		
44 74FU0	1.	0.	0.	0.	1.	0.			
	142664.	3656.	110.00	18.	0.0	0.0	100.0	0.0	0.0
	0.0	400.	2.30	40.0	0.	14.			
	141.	109.	47.	5136.	12847.	254805.	219915.	9437.	151.
	10.0	54934.	0.0	5390.	1.	5840.	6056.		
45 73CR0	1.	0.	0.	0.	1.	0.			
	24642.	307.	8.00	529.	0.0	98.0	2.0	0.0	0.0
	98.6	300.	0.83	0.0	89.	13.			
	1090.	1090.	0.	0.	0.	0.	0.	0.	0.
	10.0	6360.	0.0	0.	1.	0.	0.		
46 73CG0	1.	0.	0.	0.	1.	0.			
	43912.	900.	12.00	53.	0.0	0.0	100.0	0.0	0.0
	0.0	60.	0.83	0.0	0.	2.			
	1101.	1101.	0.	30.	58.	816.	0.	15.	0.
	67.0	6380.	0.0	0.	1.	0.	0.		
47 65BH0	1.	0.	0.	0.	1.	0.			
	2076.	760.	18.00	1308.	95.9	0.0	1.3	2.8	0.0
	98.7	122.	2.30	0.0	578.	7.			
	458.	260.	0.	0.	0.	0.	0.	0.	0.
	25.0	54934.	0.0	234.	1.	886.	6056.		
48 74FC0	1.	0.	0.	0.	1.	0.			
	125493.	1173.	25.70	985.	0.0	100.0	0.0	0.0	0.0
	100.0	300.	2.30	63.0	39.	6.			
	140.	103.	21.	3885.	14521.	321896.	61077.	1554.	0.
	20.0	54934.	0.0	2000.	1.	4417.	6056.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
49 74FJ0	1.	0.	0.	0.	1.	0.			
	32077.	1723.	28.20	1075.	0.0	91.3	8.7	0.0	0.0
	91.3	123.	2.30	78.0	3.	5.			
	280.	211.	12.	1253.	5486.	161164.	280963.	12.	0.
	15.0	54934.	0.0	0.	1.	4203.	6056.		
50 74FK0	1.	0.	0.	0.	1.	0.			
	4727.	119.	3.30	24.	90.0	0.0	10.0	0.0	0.0
	90.0	20.	2.30	0.0	8.	1.			
	1615.	617.	2.	274.	241.	7524.	746.	19.	0.
	17.0	54934.	0.0	195.	1.	123.	6056.		
51 74F00	1.	0.	0.	0.	1.	0.			
	120085.	1747.	160.00	8299.	96.9	3.1	0.0	0.0	0.0
	100.0	637.	2.30	66.0	2392.	31.			
	108.	50.	78.	5422.	11271.	471973.	533656.	2375.	0.
	23.0	54934.	0.0	10000.	1.	7764.	6056.		
52 74KA0	1.	0.	0.	0.	1.	0.			
	56037.	2625.	38.00	522.	0.0	93.9	0.0	6.1	0.0
	99.7	177.	2.30	36.0	181.	19.			
	180.	84.	20.	3307.	12436.	210326.	15489.	4024.	0.
	24.0	54934.	0.0	0.	1.	3504.	6056.		
53 74KC0	1.	0.	0.	0.	1.	0.			
	36999.	692.	16.00	1756.	82.2	17.5	0.0	0.3	0.0
	100.0	130.	2.30	0.0	1375.	18.			
	305.	193.	2.	1262.	3969.	54138.	83095.	578.	0.
	24.0	54934.	0.0	3000.	1.	3455.	6056.		
54 74CA0	1.	0.	0.	0.	1.	0.			
	19882.	1468.	38.00	2242.	85.6	13.2	1.2	0.0	0.0
	98.8	517.	2.30	0.0	29.	29.			
	506.	267.	45.	1892.	1110.	0.	0.	0.	0.
	3.0	101128.	0.0	2037.	1.	0.	0.		
55 74CB0	1.	0.	0.	0.	1.	0.			
	22770.	1476.	44.00	819.	98.9	0.0	1.1	0.0	0.0
	98.9	181.	2.30	0.0	38.	10.			
	527.	293.	53.	1594.	1415.	45347.	1697.	3.	0.
	9.0	101128.	0.0	0.	1.	14109.	148201.		
56 74CC0	1.	0.	0.	0.	1.	0.			
	17925.	477.	5.00	917.	99.1	0.3	0.6	0.0	0.0
	99.4	181.	2.30	0.0	41.	1.			
	691.	302.	184.	2120.	1627.	53789.	7453.	0.	0.
	3.0	161688.	0.0	1755.	1.	12346.	148201.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
57 74FA1	1.	0.	0.	0.	1.	0.			
	22595.	2701.	54.00	4199.	99.8	0.0	0.2	0.0	0.0
	99.8	124.	3.10	28.0	869.	101.			
	54.	36.	89.	2868.	3079.	158221.	44352.	18.	0.
	4.3	33966.	0.0	2471.	1.	7491.	33333.		
58 74EB0	1.	0.	0.	0.	1.	0.			
	37137.	950.	19.00	1779.	81.5	11.8	0.7	6.0	0.0
	99.3	135.	2.30	0.0	345.	17.			
	294.	158.	1.	1441.	3997.	84832.	29601.	155.	0.
	14.0	54934.	0.0	1118.	1.	1283.	6056.		
59 73PH0	1.	0.	0.	0.	1.	0.			
	31518.	952.	32.00	1061.	0.0	0.0	0.0	100.0	0.0
	100.0	465.	1.20	0.0	4.	12.			
	260.	146.	1.	463.	977.	27780.	0.	0.	0.
	6.0	15600.	0.0	1200.	2.	3190.	14989.		
60 73PB0	1.	0.	0.	0.	1.	0.			
	566500.	1698.	51.00	3246.	90.0	10.0	0.0	0.0	0.0
	100.0	500.	1.20	0.0	370.	27.			
	43.	30.	2.	2318.	7388.	126716.	28320.	331.	0.
	4.0	15600.	0.0	1604.	1.	3045.	14989.		
61 73PD0	1.	0.	0.	0.	1.	0.			
	139554.	4072.	145.00	726.	0.0	0.0	0.0	0.0	100.0
	100.0	3000.	1.20	0.0	2.	7.			
	51.	39.	1.	1743.	5795.	121136.	77159.	1932.	0.
	14.0	15600.	0.0	1200.	1.	20716.	14989.		
62 73PF0	1.	0.	0.	0.	1.	0.			
	264550.	2352.	51.00	2452.	88.2	11.8	0.0	0.0	0.0
	100.0	275.	1.20	0.0	1095.	34.			
	223.	141.	0.	396.	990.	20667.	0.	0.	0.
	3.0	15600.	0.0	0.	1.	3786.	14989.		
63 73PM0	1.	0.	0.	0.	1.	0.			
	49633.	1445.	33.00	707.	20.0	66.6	13.4	0.0	0.0
	86.1	145.	1.20	0.0	4.	8.			
	0.	0.	0.	794.	1523.	15840.	33974.	43.	0.
	1.0	15600.	0.0	1271.	1.	18249.	14989.		
64 71NA0	1.	0.	0.	0.	0.	1.			
	7191.	1367.	36.00	1674.	0.0	75.0	0.0	0.0	25.0
	97.6	256.	2.30	0.0	0.	11.			
	53.	34.	353.	15295.	34551.	715310.	106095.	7460.	0.
	4.8	152328.	0.0	692.	1.	215559.	148201.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	GPA	TRAIN	FHTRAIN		
65 71QU0	1.	0.	0.	0.	0.	1.			
	7191.	1367.	36.00	1674.	0.0	75.0	0.0	0.0	25.0
	97.6	256.	2.30	0.0	0.	11.			
	89.	52.	91.	5319.	13000.	247363.	53682.	3965.	0.
	5.2	85458.	0.5	692.	1.	68139.	67590.		
66 63AA0	1.	0.	0.	0.	0.	1.			
	12956.	1120.	29.00	790.	0.0	75.0	0.0	0.0	25.0
	97.0	150.	2.30	0.0	7.	11.			
	111.	67.	19.	2838.	8420.	166586.	20323.	981.	0.
	10.0	54934.	0.0	601.	1.	3701.	6056.		
67 65AA0	1.	0.	0.	0.	0.	1.			
	14271.	377.	14.00	982.	0.0	75.0	0.0	0.0	25.0
	100.0	64.	2.30	0.0	131.	21.			
	200.	138.	1.	1482.	6577.	101011.	119149.	598.	0.
	18.0	54934.	0.0	0.	1.	2032.	6056.		
68 63AG0	1.	0.	0.	0.	0.	1.			
	7579.	428.	16.30	585.	59.1	38.2	2.7	0.0	0.0
	97.3	32.	2.30	0.0	31.	7.			
	404.	240.	6.	747.	2097.	27866.	31740.	121.	0.
	21.0	54939.	0.0	461.	1.	1283.	6056.		
69 63BC0	1.	0.	0.	0.	0.	1.			
	1905.	267.	12.00	742.	53.1	7.6	0.0	39.3	0.0
	100.0	34.	2.30	0.0	73.	12.			
	132.	74.	0.	0.	0.	123904.	831.	8.	0.
	31.0	54939.	0.0	0.	1.	1793.	6056.		
70 63BF0	1.	0.	0.	0.	0.	1.			
	2957.	78.	2.00	159.	88.7	0.0	0.0	11.3	0.0
	100.0	3.	2.30	0.0	14.	4.			
	2746.	1168.	0.	102.	351.	5295.	0.	0.	0.
	6.0	54939.	0.0	201.	1.	82.	6056.		
71 71ABE	0.	1.	0.	1.	0.	0.			
	1100.	280.	7.50	214.	0.0	93.0	7.0	0.0	0.0
	93.0	7.	1.30	4.0	0.	1.			
	991.	769.	0.	172.	327.	7473.	0.	0.	0.
	0.0	34143.	0.0	159.	1.	1407.	36101.		
72 71ADA	0.	1.	0.	1.	0.	0.			
	2744.	1732.	60.00	924.	0.0	100.0	0.0	0.0	0.0
	0.0	17.	1.30	0.0	0.	17.			
	89.	75.	1.	1496.	7869.	132249.	6084.	1081.	15983.
	4.0	34143.	10.0	671.	1.	17366.	36101.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
73 73DBA	0.	1.	0.	1.	0.	0.			
	5928.	6478.	90.00	321.	0.0	75.0	0.0	0.0	25.0
	25.0	1640.	1.30	0.0	0.	14.			
	113.	93.	2.	2408.	5401.	89023.	40486.	4018.	0.
	8.0	34143.	0.0	1019.	1.	21694.	36101.		
74 71ACC	0.	1.	0.	1.	0.	0.			
	153.	86.	2.60	78.	0.0	100.0	0.0	0.0	0.0
	0.0	17.	1.30	0.0	0.	3.			
	547.	446.	2.	246.	426.	9638.	425.	33.	17.
	3.0	34143.	0.0	79.	1.	1028.	36101.		
75 73CBQ	0.	1.	0.	1.	0.	0.			
	158.	30.	1.20	38.	0.0	100.0	0.0	0.0	0.0
	0.0	34.	1.30	4.0	0.	22.			
	2849.	2849.	0.	121.	41.	1546.	392.	11.	0.
	0.0	34143.	0.0	71.	1.	216.	36101.		
76 73CEN	0.	1.	0.	1.	0.	0.			
	2762.	256.	10.50	20.	0.0	0.0	100.0	0.0	0.0
	0.0	100.	1.30	0.0	0.	1.			
	2318.	1370.	0.	205.	29.	2888.	13035.	240.	0.
	100.0	34143.	0.0	695.	1.	2435.	36101.		
77 73CFK	0.	1.	0.	1.	0.	0.			
	18720.	8200.	118.00	561.	0.0	75.0	0.0	0.0	25.0
	66.5	152.	1.30	0.0	0.	18.			
	46.	35.	5.	8682.	11565.	289184.	101147.	2844.	1445.
	3.0	34143.	0.0	5645.	1.	50259.	36101.		
78 73DAH	0.	1.	0.	1.	0.	0.			
	5720.	3060.	58.00	156.	0.0	43.0	57.0	0.0	0.0
	0.0	225.	1.30	0.0	0.	1.			
	278.	179.	21.	1214.	2184.	48447.	8266.	1304.	0.
	18.0	34143.	1.0	241.	1.	11036.	36101.		
79 73EBA	0.	1.	0.	1.	0.	0.			
	1347.	132.	3.40	120.	0.0	100.0	0.0	0.0	0.0
	86.0	34.	1.30	0.0	0.	4.			
	848.	499.	5.	235.	169.	4146.	2221.	41.	264.
	8.0	34143.	0.0	513.	1.	920.	36101.		
80 73EBF	0.	1.	0.	1.	0.	0.			
	2590.	464.	11.50	177.	0.0	100.0	0.0	0.0	0.0
	37.0	130.	1.30	0.0	0.	6.			
	115.	87.	107.	1383.	1635.	39076.	18553.	814.	714.
	24.0	34143.	0.0	299.	1.	9792.	36101.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	OPA	TRAIN	FMTRAIN		
81 71CA0	0.	1.	0.	1.	0.	0.			
	2079.	275.	7.30	290.	0.0	100.0	0.0	0.0	0.0
	100.0	6.	1.30	0.0	0.	14.			
	1325.	935.	0.	58.	120.	2619.	0.	0.	0.
	0.0	15896.	0.0	277.	1.	88.	16653.		
82 73EG0	0.	1.	0.	1.	0.	0.			
	87249.	1573.	47.40	3322.	93.0	7.0	0.0	0.0	0.0
	100.0	225.	1.30	0.0	1543.	21.			
	133.	49.	8.	3888.	1990.	44122.	123852.	994.	0.
	9.0	15896.	0.0	4843.	2.	25201.	16653.		
83 73HC0	0.	1.	0.	1.	0.	0.			
	121411.	1027.	26.00	3027.	41.7	39.0	19.3	0.0	0.0
	100.0	120.	1.30	2.0	713.	17.			
	45.	25.	40.	3605.	3016.	96847.	198165.	1835.	0.
	8.0	15895.	0.0	3563.	1.	17560.	16553.		
84 73LA0	0.	1.	0.	1.	0.	0.			
	31654.	1272.	36.00	2982.	0.0	100.0	0.0	0.0	0.0
	99.1	290.	1.30	0.0	408.	21.			
	56.	34.	2.	2934.	9036.	214865.	66358.	1092.	0.
	8.6	15896.	0.0	2110.	1.	18121.	16653.		
85 77EC0	0.	1.	0.	0.	1.	0.			
	9701.	1760.	45.00	946.	11.0	84.0	5.0	0.0	0.0
	94.7	350.	1.30	0.0	37.	15.			
	342.	266.	0.	848.	1210.	30800.	26366.	767.	0.
	9.0	34143.	0.0	3003.	1.	5681.	36101.		
86 77EE0	0.	1.	0.	0.	1.	0.			
	835.	222.	8.50	9.	0.0	0.0	100.0	0.0	0.0
	0.0	100.	1.30	0.0	0.	3.			
	6065.	5792.	0.	32.	5.	0.	0.	0.	0.
	0.0	34143.	0.0	0.	1.	0.	0.		
87 77DCA	0.	1.	0.	0.	1.	0.			
	31698.	1223.	26.40	1457.	0.0	100.0	0.0	0.0	0.0
	100.0	145.	1.30	0.0	5.	13.			
	738.	644.	0.	0.	0.	7391.	13817.	272.	0.
	17.0	34143.	0.0	2622.	1.	4707.	36101.		
88 77DB0	0.	1.	0.	0.	1.	0.			
	835.	222.	8.50	9.	0.0	0.0	100.0	0.0	0.0
	0.0	100.	1.30	0.0	0.	3.			
	6205.	5291.	0.	56.	9.	618.	0.	0.	0.
	75.0	34143.	0.0	0.	1.	108.	36101.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
89 76AEA	0.	1.	0.	0.	1.	0.			
	42000.	2666.	92.00	2375.	0.0	0.0	0.0	0.0	100.0
	98.9	1300.	0.30	11.7	105.	13.			
	435.	297.	13.	991.	2118.	29282.	96464.	1632.	19877.
	33.0	35649.	13.5	3921.	1.	33380.	36101.		
90 73KA0	0.	1.	0.	0.	1.	0.			
	10291.	622.	16.00	3241.	0.0	98.8	1.2	0.0	0.0
	98.8	200.	1.30	10.5	0.	13.			
	127.	87.	0.	2049.	3889.	84017.	9407.	231.	2816.
	6.0	15896.	2.9	882.	2.	8920.	16653.		
91 63BAA	0.	1.	0.	0.	0.	1.			
	3846.	1680.	49.00	1153.	0.0	75.0	0.0	0.0	25.0
	23.0	500.	1.30	0.0	0.	7.			
	60.	47.	1.	1867.	7411.	127023.	3191.	456.	21120.
	2.0	34143.	3.2	846.	1.	20017.	36101.		
92 63CAA	0.	1.	0.	0.	0.	1.			
	3846.	1680.	49.00	1153.	0.0	75.0	0.0	0.0	25.0
	23.0	500.	1.30	0.0	0.	7.			
	74.	60.	3.	1385.	6084.	100683.	2456.	368.	19277.
	2.0	34143.	2.5	846.	1.	17150.	36101.		
93 65BAA	0.	1.	0.	0.	0.	1.			
	3914.	1844.	29.00	1236.	0.0	76.0	1.0	8.0	15.0
	97.5	90.	1.30	5.0	0.	10.			
	235.	192.	1.	550.	1768.	16501.	4826.	210.	0.
	5.7	34143.	0.0	624.	1.	5140.	36101.		
94 61BBA	0.	1.	0.	0.	0.	1.			
	5864.	1869.	49.00	1378.	0.0	100.0	0.0	0.0	0.0
	70.0	380.	1.30	0.0	0.	13.			
	156.	133.	44.	1034.	2231.	0.	0.	0.	0.
	5.4	34143.	0.0	618.	1.	7358.	36101.		
95 61AA0	0.	1.	0.	0.	0.	1.			
	30591.	378.	13.12	195.	0.0	75.0	0.0	0.0	25.0
	100.0	150.	1.30	0.0	7.	13.			
	338.	166.	0.	492.	1345.	15806.	44390.	137.	0.
	17.0	15896.	0.0	4405.	1.	9849.	16653.		
96 61AB0	0.	1.	0.	0.	0.	1.			
	14626.	598.	23.13	432.	0.0	43.8	32.0	24.2	0.0
	100.0	150.	1.30	0.0	3.	10.			
	331.	157.	0.	620.	1718.	18849.	37636.	146.	0.
	17.0	15896.	0.0	0.	1.	10497.	16653.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHD	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
97 61AC0	0.	1.	0.	0.	0.	1.			
	12360.	135.	4.17	471.	0.0	100.0	0.0	0.0	0.0
	100.0	70.	1.30	11.0	33.	6.			
	230.	157.	5.	451.	909.	23250.	5010.	55.	0.
	4.0	15896.	0.0	566.	1.	2033.	16653.		
98 72AA0	0.	1.	0.	0.	0.	1.			
	556.	36.	1.00	38.	0.0	100.0	0.0	0.0	0.0
	100.0	9.	1.30	0.0	0.	1.			
	5299.	2649.	0.	12.	52.	915.	0.	0.	0.
	0.0	15896.	0.0	0.	1.	193.	16653.		
99 72AC0	0.	1.	0.	0.	0.	1.			
	12302.	68.	4.00	62.	0.0	75.0	0.0	0.0	25.0
	96.2	10.	1.30	0.0	0.	2.			
	994.	691.	0.	209.	525.	10407.	0.	0.	0.
	0.6	15896.	0.0	881.	1.	473.	16653.		
100 71CA0	0.	0.	1.	1.	0.	0.			
	3265.	1734.	60.00	924.	0.0	75.0	0.0	0.0	25.0
	0.0	500.	1.20	0.0	5.	16.			
	70.	58.	34.	10874.	39261.	706467.	74086.	6437.	13262.
	4.0	187026.	0.0	850.	1.	130528.	181271.		
101 72EAA	0.	0.	1.	1.	0.	0.			
	3700.	6478.	87.50	321.	0.0	75.0	0.0	0.0	25.0
	25.0	1640.	1.20	0.0	0.	39.			
	138.	111.	181.	9962.	27453.	617763.	62248.	16506.	2054.
	16.0	187026.	0.0	993.	1.	114660.	181271.		
102 72ECA	0.	0.	1.	1.	0.	0.			
	2051.	4243.	63.38	4363.	0.0	100.0	0.0	0.0	0.0
	0.0	160.	1.20	0.0	0.	1.			
	486.	275.	0.	0.	0.	99923.	7884.	1803.	0.
	6.0	187026.	0.0	478.	1.	18428.	181271.		
103 72BPO	0.	0.	1.	1.	0.	0.			
	253380.	2475.	75.00	4505.	30.0	69.0	1.0	0.0	0.0
	99.6	707.	1.20	4.0	371.	24.			
	120.	60.	43.	4192.	8015.	130665.	1162073.	14008.	275628.
	0.0	49515.	6.0	10787.	1.	202150.	42105.		
104 71JA0	0.	0.	1.	1.	0.	0.			
	6247.	479.	12.80	1013.	0.0	99.0	1.0	0.0	0.0
	99.0	175.	1.20	0.0	0.	10.			
	262.	241.	28.	1058.	4286.	51129.	1831.	106.	416.
	2.0	49515.	0.0	267.	2.	11957.	42105.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER UPRICE SS MTBF NRTS	BOMBER VOLUME POWDIS MTBMA FLYHRS	CARGO WEIGHT UFACT MMHSCH COND	NAV CCOUNT BITFIT MMHUNS SRA	SENS DIGTAL IC MMHSHO QPA	COMM ANALOG SRU LSCFLD TRAIN	EM LSCSRC FHTRAIN	PS LSCPAC	XTMR LSCCON
105 71LA0	0.	0.	1.	1.	0.	0.			
	34862.	1260.	32.00	2743.	55.0	33.0	0.0	0.0	12.0
	99.6	265.	1.20	0.0	607.	15.			
	155.	134.	32.	2172.	4030.	104855.	78950.	1771.	0.
	17.0	49515.	0.0	1638.	2.	26025.	42105.		
106 72DN0	0.	0.	1.	1.	0.	0.			
	100450.	1511.	39.86	1044.	87.0	12.0	1.0	0.0	0.0
	98.7	850.	1.20	6.0	0.	12.			
	311.	106.	21.	2270.	1706.	233370.	0.	0.	0.
	8.0	49515.	0.0	13582.	2.	5768.	42105.		
107 72AC0	0.	0.	1.	1.	0.	0.			
	16793.	432.	31.00	592.	0.0	99.0	1.0	0.0	0.0
	99.0	851.	1.20	4.0	11.	13.			
	464.	237.	8.	845.	1338.	29285.	18422.	829.	0.
	30.0	49515.	0.0	2866.	1.	3869.	42105.		
108 71716	0.	0.	1.	1.	0.	0.			
	1268.	294.	7.50	214.	0.0	100.0	0.0	0.0	0.0
	100.0	20.	1.20	4.0	0.	1.			
	1436.	1156.	23.	1083.	1584.	32797.	3483.	107.	0.
	4.0	202713.	0.0	252.	1.	327.	159610.		
109 7131D	0.	0.	1.	1.	0.	0.			
	2745.	1734.	60.00	924.	0.0	75.0	0.0	0.0	25.0
	0.0	500.	1.20	0.0	0.	35.			
	102.	87.	302.	11074.	30275.	552103.	41304.	7488.	47495.
	5.0	202713.	0.0	604.	1.	5.	669015.		
110 72RF0	0.	0.	1.	1.	0.	0.			
	1602.	399.	14.00	328.	0.0	0.0	0.0	100.0	0.0
	30.0	860.	1.20	0.0	0.	4.			
	329.	227.	124.	2494.	3265.	84589.	6860.	237.	0.
	4.0	202713.	0.0	482.	1.	6111.	159610.		
111 72RB0	0.	0.	1.	1.	0.	0.			
	2185.	368.	9.00	88.	0.0	33.0	67.0	0.0	0.0
	0.0	860.	1.20	0.0	0.	1.			
	2144.	1238.	25.	492.	667.	16183.	2136.	116.	197.
	9.0	202713.	1.0	161.	1.	1691.	159610.		
112 71JCE	0.	0.	1.	1.	0.	0.			
	7025.	91.	2.10	26.	0.0	50.0	50.0	0.0	0.0
	50.0	7.	1.20	0.0	0.	1.			
	1520.	944.	0.	282.	318.	8529.	0.	0.	0.
	0.0	48360.	0.0	388.	2.	1547.	42105.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHC	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
113 72AE0	0.	0.	1.	1.	0.	0.			
	80945.	2267.	58.00	4275.	100.0	0.0	0.0	0.0	0.0
	100.0	333.	1.20	0.0	1104.	98.			
	0.	0.	96.	3764.	2000.	69308.	66544.	0.	0.
	15.0	48360.	0.0	3446.	1.	24970.	42105.		
114 72CC0	0.	0.	1.	1.	0.	0.			
	27391.	1097.	26.00	1289.	70.0	30.0	0.0	0.0	0.0
	100.0	85.	1.20	0.0	270.	37.			
	331.	227.	1.	729.	567.	25356.	29155.	335.	0.
	27.0	48360.	0.0	3481.	1.	6612.	42105.		
115 71ZA0	0.	0.	1.	1.	0.	0.			
	8027.	748.	26.50	2060.	75.0	0.0	0.0	0.0	25.0
	99.9	100.	1.20	0.0	354.	1.			
	1577.	904.	0.	0.	0.	0.	9.	0.	0.
	0.0	154575.	0.0	650.	1.	2892.	159610.		
116 71Z80	0.	0.	1.	1.	0.	0.			
	1538.	154.	5.00	669.	50.0	50.0	0.0	0.0	0.0
	100.0	25.	1.20	0.0	85.	1.			
	2146.	1472.	7.	238.	214.	5157.	1524.	183.	0.
	0.0	154575.	0.0	650.	1.	437.	159610.		
117 71ZD0	0.	0.	1.	1.	0.	0.			
	516.	94.	2.00	94.	0.0	100.0	0.0	0.0	0.0
	100.0	10.	1.20	0.0	17.	1.			
	6441.	3864.	0.	105.	182.	2001.	0.	0.	0.
	0.0	154575.	0.0	80.	1.	164.	159610.		
118 65BAA	0.	0.	1.	0.	0.	1.			
	3914.	1844.	29.00	1236.	0.0	76.0	1.0	8.0	15.0
	97.5	90.	1.20	5.0	77.	11.			
	212.	158.	9.	3220.	8990.	161634.	22218.	1296.	0.
	3.0	187026.	0.0	624.	1.	31224.	181271.		
119 63AF0	0.	0.	1.	0.	0.	1.			
	4033.	1680.	51.00	1186.	0.0	75.0	0.0	0.0	25.0
	23.0	502.	1.20	0.0	0.	13.			
	62.	46.	48.	20021.	70447.	249024.	54839.	5186.	69426.
	2.6	187026.	0.3	697.	2.	209869.	181271.		
120 63AA0	0.	0.	1.	0.	0.	1.			
	10712.	1120.	41.00	790.	0.0	75.0	0.0	0.0	25.0
	97.0	150.	1.20	0.0	7.	12.			
	150.	116.	89.	1401.	3769.	75369.	2253.	155.	0.
	1.8	49515.	0.0	589.	2.	8652.	42105.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER UPRICE SS MTBF NRTS	BOMBER VOLUME POWDIS MTBMA FLYHRS	CARGO WEIGHT UFACT MMHSCH COND	NAV CCOUNT BITFIT MMHUNS SRA	SENS DIGTAL IC MMHSHO QPA	COMM ANALOG SRU LSCFLD TRAIN	 EM LSCSRC FHTRAIN	 PS LSCPAC	 XTMR LSCCON
121 63121	0.	0.	1.	0.	0.	1.			
	3846.	1680.	49.00	1153.	0.0	75.0	0.0	0.0	25.0
	23.0	500.	1.20	0.0	0.	7.			
	105.	92.	370.	6457.	20707.	293691.	17658.	2264.	52546.
	8.1	190352.	0.0	1692.	1.	44250.	159610.		
122 63AAA	0.	0.	1.	0.	0.	1.			
	6345.	242.	9.00	1615.	44.0	37.0	0.0	0.0	19.0
	100.0	35.	1.20	0.0	61.	17.			
	408.	244.	112.	2153.	981.	50695.	4508.	0.	0.
	30.0	114345.	0.0	565.	1.	655.	159610.		
123 55AL0	0.	0.	1.	0.	0.	1.			
	38048.	1682.	40.00	381.	68.7	11.9	0.0	19.4	0.0
	100.0	290.	1.20	44.0	290.	20.			
	211.	133.	81.	1115.	1143.	33738.	66767.	2362.	0.
	29.0	48630.	0.0	1790.	1.	8511.	42105.		
124 55AV0	0.	0.	1.	0.	0.	1.			
	103000.	1549.	38.00	725.	75.4	0.0	0.0	24.6	0.0
	100.0	300.	1.20	15.0	192.	64.			
	94.	72.	17.	1839.	843.	31637.	29538.	663.	0.
	13.0	48630.	0.0	1790.	1.	9496.	42105.		
125 61AA0	0.	0.	1.	0.	0.	1.			
	24205.	389.	13.20	195.	0.0	75.0	0.0	0.0	25.0
	100.0	150.	1.20	0.5	7.	17.			
	250.	206.	30.	1843.	3446.	88377.	0.	0.	0.
	2.0	48630.	0.0	3830.	2.	11957.	42105.		
126 61AE0	0.	0.	1.	0.	0.	1.			
	6958.	135.	4.30	471.	0.0	100.0	0.0	0.0	0.0
	100.0	70.	1.20	0.0	33.	7.			
	338.	272.	26.	1237.	1800.	42190.	6415.	88.	0.
	5.0	48630.	0.0	551.	2.	6682.	42105.		
127 62AA0	0.	0.	1.	0.	0.	1.			
	3175.	564.	15.90	1116.	0.0	75.0	0.0	0.0	25.0
	100.0	263.	1.20	0.0	0.	16.			
	636.	590.	11.	585.	1459.	30116.	918.	56.	0.
	6.0	48630.	0.0	297.	2.	5064.	42105.		
128 64211	0.	0.	1.	0.	0.	1.			
	833.	146.	4.00	37.	0.0	100.0	0.0	0.0	0.0
	100.0	7.	1.20	0.0	0.	1.			
	1372.	809.	94.	578.	390.	14304.	439.	11.	0.
	0.0	220822.	0.0	120.	1.	0.	0.		

APPENDIX C

ALPOS VALIDATION DATA

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA

	FIGTER	BOMBER	CARGO	NAV	SENS	COMM			
	UPRICE	VOLUME	WEIGHT	CCOUNT	DIGTAL	ANALOG	EM	PS	XTMR
	SS	POWDIS	UFACT	BITFIT	IC	SRU			
	MTBF	MTBMA	MMHSCH	MMHUNS	MMHSHO	LSCFLD	LSCSRC	LSCPAC	LSCCON
	NRTS	FLYHRS	COND	SRA	QPA	TRAIN	FHTRAIN		
201 71BA0	1.	0.	0.	1.	0.	0.			
	5514.	1025.	43.30	1379.	0.0	75.0	0.0	0.0	0.0
	78.0	311.	2.30	0.0	0.	0.			
	56.	49.	10.	997.	2894.	53447.	22340.	1051.	1099.
	9.1	16727.	0.0	1071.	1.	12736.	19492.		
202 74BC0	1.	0.	0.	0.	1.	0.			
	8046.	585.	12.50	878.	0.0	87.0	13.0	0.0	0.0
	87.0	58.	2.30	2.0	0.	0.			
	86.	55.	249.	5631.	7400.	179780.	25791.	823.	453.
	2.8	152710.	0.0	345.	1.	57417.	148201.		
203 74BE0	1.	0.	0.	0.	1.	0.			
	3398.	324.	9.30	58.	0.0	0.0	0.0	100.0	0.0
	100.0	75.	2.30	0.0	0.	0.			
	694.	291.	4.	983.	846.	30289.	8746.	103.	0.
	6.5	152710.	0.0	1021.	1.	4507.	148201.		
204 74BG0	1.	0.	0.	0.	1.	0.			
	9831.	563.	11.80	209.	0.0	77.0	23.0	0.0	0.0
	77.0	24.	2.30	15.0	0.	0.			
	155.	107.	480.	3213.	6890.	159706.	19672.	763.	0.
	2.9	152710.	0.0	740.	1.	41152.	148201.		
205 74BH0	1.	0.	0.	0.	1.	0.			
	9910.	777.	40.80	73.	0.0	72.0	28.0	0.0	0.0
	69.0	1800.	2.30	6.0	0.	0.			
	183.	119.	356.	2851.	4709.	133027.	8426.	234.	0.
	2.1	152710.	0.0	1906.	1.	31550.	148201.		
206 65BA0	1.	0.	0.	0.	0.	1.			
	6650.	739.	19.00	900.	0.0	75.0	0.0	0.0	0.0
	100.0	254.	2.30	0.0	0.	0.			
	145.	105.	0.	337.	1117.	14228.	16247.	425.	0.
	13.3	12296.	0.0	907.	1.	3828.	14989.		
207 73JC0	0.	1.	0.	1.	0.	0.			
	23015.	5733.	101.00	2412.	0.0	68.0	7.0	0.0	25.0
	93.0	2200.	1.20	7.0	13.	16.			
	78.	48.	20.	2267.	3548.	72293.	32482.	2120.	0.
	9.0	15896.	0.0	817.	1.	10357.	16653.		
208 73JF0	0.	1.	0.	1.	0.	0.			
	6283.	158.	3.00	62.	0.0	63.0	37.0	0.0	0.0
	63.0	20.	1.20	2.0	0.	1.			
	1060.	568.	0.	147.	65.	3126.	0.	0.	0.
	0.0	15896.	0.0	885.	1.	228.	16653.		

ALPOS
MULTIPLE REGRESSION ANALYSIS DATA
(CONTINUED)

	FIGTER UPRICE SS MTBF NRTS	BOMBER VOLUME POWDIS MTBMA FLYHRS	CARGO WEIGHT UFACT MMHSCH COND	NAV CCOUNT BITFIT MMHUNS SRA	SENS DIGTAL IC MMHSHO QPA	COMM ANALOG SRU LSCFLD TRAIN	EM LSCSRC FHTRAIN	PS LSCPAC	XTMR LSCCON
209 71CA0	0.	0.	1.	1.	0.	0.			
	34207.	1291.	35.90	1711.	91.2	0.0	0.0	8.8	0.0
	100.0	240.	1.30	0.4	903.	58.			
	124.	98.	7.	1577.	3026.	44766.	76110.	861.	0.
	8.0	48630.	0.0	3198.	1.	2814.	42105.		
210 71GA0	0.	0.	1.	1.	0.	0.			
	704.	286.	7.10	478.	0.0	100.0	0.0	0.0	0.0
	100.0	66.	1.30	0.0	0.	1.			
	797.	760.	0.	447.	869.	18741.	0.	0.	0.
	1.9	48630.	0.0	331.	2.	2884.	42105.		
211 65AA0	0.	0.	1.	0.	0.	1.			
	3175.	1657.	31.00	1230.	0.0	76.0	1.0	8.0	15.0
	97.0	90.	1.30	0.0	74.	26.			
	269.	236.	2.	717.	1728.	34944.	0.	0.	0.
	0.8	48630.	0.0	267.	1.	3517.	42105.		

APPENDIX D

COMPUTER PROGRAM

DOCUMENTATION

```
C*****************************************************************************
C      ****************************************************************
C
C      A V I O N I C S   L A B O R A T O R Y   P R E D I C T I V E
C         O P E R A T I O N S    A N D    S U P P O R T   M O D E L
C                         A L P O S
C                     ( V E R S I O N  2 )
C
C
C      ****************************************************************
       PROGRAM ALPOS (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C BLK IS COMMON FOR ITEMS IN DATA STATEMENTS
       COMMON/BLK/KEYL,EXPAND,BLANK,STAR,A
C CVR1 IS COMMON FOR RUN TITLE FOR THE COVER SUBROUTINE
       COMMON / CVR1 / ANAME(2)
C IVAR IS COMMON FOR THE INDEPENDENT AND INDEPENDENT VARIABLES AND IS
C USED WITH THE ESTIM SUBROUTINE
       COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
      +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
C SP1 IS COMMON FOR OPERATING HOURS FROM SPARES SUBROUTINE
       COMMON /SP1/ OPHR,ACSON
       COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
      $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
       COMMON/WNRT/ENRTS
       COMMON/VNRT/LFDNRT,THHNRT,SHPNRT
       DIMENSION KEYL(4),NLPA(4),AXP(6),HOG(19),CTE(5),A(6),EXPAND(15)
       DIMENSION ALSC(25),ATRN(25),ANSE(25),ATOT(25),TOTSP(25),ASECST(25)
       REAL LFDNRT
       REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
       INTEGER ALT,QTY,CERSET,FNRTS,CKNRTS
C KEYL IS ARRAY OF ALLOWABLE KEY LETTERS
       DATA KEYL/4HS    ,4HA    ,4HL    ,4HT
C EXPAND IS ARRAY OF AVIONICS AREA AND AIRCRAFT TYPE NAMES
       DATA EXPAND/4HCOMM,4HUNIC,4HATIO,4HNS  ,4HNAVI,4HGATI,4HON  ,4HSEN
      $S,4HORY ,4HFIGH,4HTER ,4HBOMB,4HER  ,4HCARG,4HO   /
C A IS ARRAY OF IDENTIFIERS FOR AVIONICS AREAS AND AIRCRAFT TYPES
       DATA A/4HC   ,4HN   ,4HS   ,4HF   ,4HB   ,4HC   /
       DATA BLANK/4H    /,STAR/4H****/
C IIN IS CHANNEL NUMBER FOR CARD READER
       IIN=5
C IOUT IS CHANNEL NUMBER FOR LINE PRINTER
       IOUT=6
C IPAGE IS PAGE NUMBER
       IPAGE=1
C READ TITLE CARD
       READ (IIN,1110) KEY,ANAME
 1110  FORMAT(A1,2A10)
C CHECK KEY LETTER - IF NOT 'T' STOP RUN
       IF (KEY.EQ."T") GO TO 50
       WRITE (IOUT,1120)
 1120  FORMAT (///5X,"******TITLE CARD MISSING - RUN TERMINATED")
       GO TO 950
C PRINT COVER PAGE
   50  CALL COVER (IOUT)
   60  CONTINUE
C READ SYSTEM CARD - KEY LETTERS
C      CM - COMMAND
C      AC - AIRCRAFT TYPE
```

```
C     AA - AVIONICS AREA
C     NLPA IS NUMBER OF LRU'S PER ALTERNATIVE - MAXIMUM ALLOWED = 20
C     ALT IS NUMBER OF ALTERNATIVES - MAXIMUM ALLOWED = 4
C     QTY IS QUANTITY OF SYSTEMS REQUIRED FOR AN ALTERNATIVE
      READ (IIN,1000) KEY,QTY,CM,AC,AA,ALT,(NLPA(I),I=1,4),OPHR,ACSQN,
     $CERSET,FNRTS,CKNRTS
 1000 FORMAT(A1,1X,I4,3A1,I1,4I2,F6.1,I4,1X,I2,1X,I1,1X,I1)
C CERSET IS USED TO SELECT A SET OF RELATIONSHIPS WHERE:
C                                             1 IS THE PHASE 1 CERS
C                                             2 IS THE PHASE 2 CERS
C FNRTS IS USED TO SELECT BETWEEN EITHER CALCULATED OR INPUT NRTS WHERE:
C                                              0 CALCULATED
C                                              1 INPUT
C CKNRTS ALLOWS THE USER TO CHOOSE BETWEEN THE SUBROUTINES WITHOUT NRTS
C                           AND THOSE WITH NRTS
C                            0 IS WITHOUT
C                            1 IS WITH
C CHECK KEY LETTER - IF NOT 'S' STOP RUN
      IF(KEY.EQ.KEYL(1)) GO TO 100
      WRITE(IOUT,2000)
 2000 FORMAT(///5X,"******SYSTEM CARD MISSING - RUN TERMINATED")
      GO TO 950
  100 CONTINUE
C CHECK THAT NUMBER OF ALTERNATIVES IS LESS THAN OR EQUAL TO 4
      IF(ALT.LE.4) GO TO 110
      WRITE (IOUT,2100)
 2100 FORMAT(///5X,"******NUMBER OF ALTERNATIVES GREATER THAN 4 - FIRST
     $4 CONSIDERED")
      ALT=4
C CHECK THAT NUMBER OF LRU'S PER ALTERNATIVE IS LESS THAN OR EQUAL TO 20
  110 DO 130 I=1,ALT
      IF(NLPA(I).LE.20) GO TO 130
      WRITE (IOUT,2200) I
 2200 FORMAT (///5X,"******NUMBER OF LRUS  FOR ALTERNATIVE",I3," GREATER
     $THAN LIMIT - FIRST 20 CONSIDERED")
      NLPA(I)=20
  130 CONTINUE
C OUTPUT SYSTEM VARIABLES
      WRITE (IOUT,2300) IPAGE
 2300 FORMAT (1H1,T46,"PREDICTIVE AVIONICS O & M COST MODEL"/T60,
     $"VERSION 2"/T34,"DEVELOPED BY WESTINGHOUSE FOR THE AIR FORCE AVION
     $ICS LABORATORY"/T50,"UNDER CONTRACT F33615-77-C-1105"/T62,
     $"PAGE:",I3//)
      IPAGE=IPAGE+1
C INITIALIZE DUMMY VARIABLES ICOM,ISEN, AND INAV
      ICOM = 0
      ISEN = 0
      INAV = 0
C EXPAND AVIONICS AREA, AA
      DO 140 I=1,3
      IF(AA.EQ.A(I)) GO TO 150
  140 CONTINUE
C PRINT ERROR MESSAGE FOR INVALID AVIONICS AREA
C NOTE: ****** DEFAULTS TO COMMUNICATIONS ******
      WRITE (IOUT,2400)
 2400 FORMAT(///5X,"AVIONICS AREA DOES NOT CORRESPOND- DEFAULT-COMMUNICA
     $TIONS")
```

```
      AXP(1)=STAR
      AXP(2)=STAR
      AXP(3)=STAR
      AXP(4)=STAR
C SET AVIONICS AREA TO COMMUNICATIONS - DEFAULT VALUE
      AA=A(1)
      ICOM = 1
      GO TO 190
C SEND TO CORRECT NAME FOR AVIONICS AREA
  150 GO TO (160,170,180),I
C SET AVIONICS AREA NAME TO COMMUNICATIONS
  160 DO 165 J=1,4
  165 AXP(J)=EXPAND(J)
      ICOM = 1
      GO TO 190
C SET AVIONICS AREA NAME TO NAVIGATION
  170 DO 175 J=1,3
  175 AXP(J)=EXPAND(J+4)
      AXP(4)=BLANK
      INAV = 1
      GO TO 190
C SET AVIONICS AREA NAME TO SENSORY
  180 AXP(1)=EXPAND(8)
      AXP(2)=EXPAND(9)
      AXP(3)=BLANK
      AXP(4)=BLANK
      ISEN = 1
  190 CONTINUE
C INITIALIZE DUMMY VARIABLES IBOM,ICAR, AND IFIG
      IBOM = 0
      ICAR = 0
      IFIG= 0
C EXPAND AIRCRAFT TYPE - AC
      DO 200 I=4,6
      IF(AC.EQ.A(I)) GO TO 210
  200 CONTINUE
C PRINT ERROR MESSAGE FOR INVALID AIRCRAFT TYPE
C NOTE: ****** DEFAULTS TO FIGHTER ******
      WRITE (IOUT,2500)
 2500 FORMAT(///5X,"AIRCRAFT TYPE DOES NOT CORRESPOND-DEFAULT-FIGHTER")
C PUT STARS IN AIRCRAFT TYPE NAME
      AXP(5)=STAR
      AXP(6)=STAR
C SET AIRCRAFT TYPE TO FIGHTER - DEFAULT VALUE
      AC=A(4)
      IFIG = 1
      GO TO 250
  210 I=I-3
C SEND TO CORRECT NAME FOR AIRCRAFT TYPE
      GO TO (220,230,240),I
C SET AIRCRAFT TYPE NAME TO FIGHTER
  220 AXP(5)=EXPAND(10)
      AXP(6)=EXPAND(11)
      IFIG = 1
      GO TO 250
C SET AIRCRAFT TYPE NAME TO BOMBER
  230 AXP(5)=EXPAND(12)
```

```
      AXP(6)=EXPAND(13)
      IBOM = 1
      GO TO 250
C SET AIRCRAFT TYPE NAME TO CARGO
  240 AXP(5)=EXPAND(14)
      AXP(6)=EXPAND(15)
      ICAR = 1
  250 CONTINUE
C CALCULATE FACTORS FOR MAC AIRCRAFT
      IF (CM .NE."M") GO TO 10
      IF (ACSQN.EQ.0.) ACSQN=18.
      IF (OPHR.EQ.0.) OPHR=55.
      GO TO 30
C CALCULATE FACTORS FOR SAC AIRCRAFT
   10 IF (CM .NE."S") GO TO 20
      IF (ACSQN.EQ.0.) ACSQN=17.
      IF (OPHR.EQ.0.) OPHR=34.
      GO TO 30
C CALCULATE FACTORS FOR TAC AIRCRAFT
   20 IF (CM .NE."T") WRITE (IOUT,1001)
 1001 FORMAT (///5X,"COMMAND TYPE DOES NOT CORRESPOND-DEFAULT-TAC")
      IF (ACSQN.EQ.0.) ACSQN=75.
      IF (OPHR.EQ.0.) OPHR=21.
   30 CONTINUE
C OUTPUT TABLE OF SYSTEM INPUT VARIABLES
      WRITE (IOUT,2600) QTY,CM,(AXP(J),J=1,6),OPHR,ACSQN,ALT,NLPA(1)
 2600 FORMAT (////,T54,"SYSTEM INPUT VARIABLES",///T43,"QUANTITY OF SYST
     $EMS",5X,I4//T43,"COMMAND",18X,A1,"AC"//T43,"AVIONICS AREA",12X,4A4
     $//T43,"AIRCRAFT TYPE",12X,2A4//T43,"OP/HR PER A/C PER MONTH",2X,F6
     $.1//T43,"NO OF SYS PER SQN/WING",3X,F5.0//T43,"NUMBER OF ALTERNATI
     $VES",3X,I1//T43,"ALTERNATIVE ONE LRUS",4X,I2)
C IF ONE ALTERNATIVE, SKIP PRINT STATEMENTS FOR ADDITIONAL ALTERNATIVES
      IF(ALT.LT.2) GO TO 251
C PRINT NUMBER OF LRUS FOR ALTERNATIVE TWO
      WRITE (IOUT,2610) NLPA(2)
 2610 FORMAT (/T43,"ALTERNATIVE TWO LRUS",4X,I2)
C IF TWO ALTERNATIVES, SKIP PRINT STATEMENT FOR ADDITIONAL ALTERNATIVES
      IF(ALT.LT.3) GO TO 251
C PRINT NUMBER OF LRUS FOR ALTERNATIVE THREE
      WRITE (IOUT,2620) NLPA(3)
 2620 FORMAT (/T43,"ALTERNATIVE THREE LRUS",4X,I2)
C IF THREE ALTERNATIVES, SKIP PRINT STATEMENT FOR FOUR ALTERNATIVES
      IF(ALT.LT.4) GO TO 251
C PRINT NUMBER OF LRUS FOR ALTERNATIVE FOUR
      WRITE (IOUT,2630) NLPA(4)
 2630 FORMAT (/T43,"ALTERNATIVE FOUR  LRUS",4X,I2)
  251 CONTINUE
      IF(CERSET.EQ.1) GO TO 252
      IF(CERSET.EQ.2) GO TO 252
      WRITE(IOUT,2635)
 2635 FORMAT(///5X,"...ERROR...CERSET HAS AN UNEXCEPTABLE VALUE...")
      WRITE(IOUT,2636)
 2636 FORMAT(///5X,"............NOT A 1 OR A 2...PROGRAM IS TERMINATED")
      GO TO 950
  252 WRITE(IOUT,2637) CERSET
 2637 FORMAT(///5X,"...NOTE: ESTIMATING RELATIONSHIPS DEVELOPED IN PHASE
     $ ",I2," ARE BEING EXECUTED...")
```

```
      IF(FNRTS.EQ.1) GO TO 253
      IF(FNRTS.EQ.0) GO TO 254
      FNRTS=0
      WRITE(IOUT,2638)
 2638 FORMAT(///5X,"...UNEXCEPTABLE VALUE FOR NRTS INPUT INDICATOR...")
      WRITE(IOUT,2639)
 2639 FORMAT(5X,"...NOT A 0 OR 1...DEFAULTS TO A 0...")
      GO TO 254
  253 WRITE(IOUT,2640)
 2640 FORMAT(///5X,"...INPUT VALUE OF NRTS FOR EACH LRU IS BEING USED.")
      GO TO 255
  254 WRITE(IOUT,2641)
 2641 FORMAT(///5X,"...CALCULATED VALUE OF NRTS FOR EACH LRU IS BEING US
     $ED...")
  255 CONTINUE
C LOOP FOR EACH ALTERNATIVE
      DO 900 I=1,ALT
C READ HEADING CARD AND CHECK FOR KEYLETTER A
  260 READ (IIN,1100) KEY,(HDG(J),J=1,19)
 1100 FORMAT (20A4)
C EXIT IF END OF FILE
      IF (EOF(IIN)) 950,261
  261 CONTINUE
C CHECK KEYLETTER
      IF(KEY.EQ.KEYL(2)) GO TO 270
C PRINT ERROR MESSAGE FOR FAULTY KEYLETTER AND READ NEXT CARD
      WRITE (IOUT,2700) I
 2700 FORMAT (1H1,5X,"******MISSING CARD FOR ALTERNATIVE",1X,I2,1X,"DATA
     $ SET IGNORED")
      GO TO 900
C PRINT HEADING FOR LRU INPUT DATA PRINTOUT
  270 WRITE (IOUT,2300) IPAGE
      IPAGE=IPAGE+1
      WRITE (IOUT,2800)
 2800 FORMAT (////,T58,"LRU INPUT VARIABLES")
      WRITE (IOUT,2900) (HDG(K),K=1,19)
 2900 FORMAT (///,T36,19A4,///)
C SET COUNTER EQUAL TO NUMBER OF LRUS
      N=NLPA(I)
C CALL SURROUTINE TO PRINT LRU INPUT DATA
C THIS VARIES DEPENDING ON THE VALUE OF CERSET
      IF(CERSET.EQ.2)276,275
  275 CALL PRINT1 (IIN,IOUT,N)
      GO TO 277
  276 CALL PRINT1 (IIN,IOUT,N)
C PRINT HEADING FOR MODEL OUTPUT
  277 WRITE (IOUT,2300) IPAGE
      IPAGE=IPAGE+1
      IF(CERSET.EQ.2) GO TO 6001
      WRITE (IOUT,6000)
 6000 FORMAT(60X,"MODEL OUTPUTS"//6X,"COMP","   NO OF ** ",5X,"LSC",5X,
     +"TRN",                     36X,"ANNUAL    ANNUAL    ANNUAL    TOT
     +AL     SPARES       SE"/ 3X,"DENSITY  SPARES **   PER OH  PER OH
     +  MTBF    MTBMA    MMHOH    NRTS        LSC  TNG COST   SE COST ANN.
     +COST       COST          COST"//)
      GO TO 6003
 6001 WRITE(IOUT,6002)
```

```
 6002 FORMAT(60X,"MODEL OUTPUTS"//6X,"COMP","   NO OF ** ",1X,"TOT LSC",
     $ 2X,"FLD LSC",4X,"DEPOT",4X,"TRN",27X,"TOT",7X,"UNS",7X,"SHOP"/3X,
     $ "DENSITY  SPARES **  PER OH   PER OH   REP COST   PER OH     MTBF
     $     MTBMA      MMHOH      MMHOH      MMHOH        NRTS")
      IF(CKNRTS.EQ.0) GO TO 6003
      WRITE(IOUT,6035)
 6035 FORMAT(/32X,"(W/NRTS)",40X,"(W/NRTS)",12X,"(W/NRTS)"//)
 6003 CONTINUE
C     INITIALIZING TOTAL RECURRING AND NON-RECURRING COST
      TRCOST=0.
      TNCOST=0.
C     INITIALIZING FIGURES OF MERIT
      TOTLSC=0.
      TOTFLD=0.
      TOTDEP=0.
      TOTTRN=0.
      STMTBF=0.
      TOMTBF=0.
      SMTBMA=0.
      TMTBMA=0.
      TMMHOH=0.
      UMMHOH=0.
      SMMHOH=0.
C PREDICT COSTS AND R AND M FACTORS FOR EACH LRU
      DO 300 J=1,N
C READ LRU INOUT DATA
      READ (IIN,1200) KEY,ID,UP,V,W,CC,(CTE(K),K=1,5),ENRTS,FSS,PD,
     $BF,UF,UPA
 1200 FORMAT (A2,A6,F8.0,F6.0,F6.1,F6.0,5F4.0,2F4.0,F6.0,F4.0,F4.2,F4.0)
C CHECK KEYLETTER FOR LRU DATA CARD
      IF(KEY.EQ.KEYL(3)) GO TO 280
C IF NOT LRU DATA CARD, PRINT ERROR MESSAGE AND SKIP TO NEXT CARD
      WRITE (IOUT,3000)
 3000 FORMAT (///5X,"****** LRU KEY LETTER DOES NOT MATCH-DATA SET IGNOR
     $ED")
      GO TO 900
C RENAME COMPONENTS TYPE AND TECHNOLOGY FOR USE IN ESTIM
  280 FDI = CTE(1)
      FAN = CTE(2)
      FEM = CTE(3)
      FPS = CTE(4)
      FXR = CTE(5)
C CALL SUBROUTINE TO MAKE PREDICTIONS
      IF(CERSET.EQ.2)314,313
  313 CALL ESTIM
      GO TO 315
  314 CONTINUE
C     CALCULATE INDICATOR VARIABLES USED IN PHASE 2 RELATIONSHIPS
      IFGNAV=IFIG*INAV
      IFGSEN=IFIG*ISEN
      IFGCOM=IFIG*ICOM
      IBMNAV=IBOM*INAV
      IBMSEN=IBOM*ISEN
      IBMCOM=IBOM*ICOM
      ICRNAV=ICAR*INAV
      ICRCOM=ICAR*ICOM
      CALL ESTIM2
```

```
      IF(FNRTS.EQ.1.AND.CKNRTS.EQ.1) GO TO 319
      CALL ESTLFD2
      CALL ESTMMH2
      CALL ESTMSH2
      GO TO 315
  319 CONTINUE
      CALL ESTLFDN
      CALL ESTMMHN
      CALL ESTMSHN
  315 CONTINUE
      IF(FNRTS.EQ.0) GO TO 316
      ANRTS=ENRTS
      GO TO 317
  316 IF(CERSET.EQ.1) CALL ESTNRT
      IF(CERSET.EQ.2) CALL ESTNRT2
C SET LIMITS ON NRTS AND MMHOH
      IF (ANRTS.LT.0.) ANRTS=0.
      IF (ANRTS.GT.100.) ANRTS=100.
      IF (AMHTOH.LT.0.) AMHTOH=0.
C CONVERT NRTS TO A FRACTION TO CALCULATE SPARES
  317 CONTINUE
      ANRTS=ANRTS/100.
C CALL SUBROUTINE TO CALCULATE SPARES COSTS
      CALL SPARES (AMTBMA,QTY,QPA,UP,SPARS,TSPAR,ANRTS,IOUT)
C CALL SUBROUTINE TO CALCULATE SUPPORT EQUIPMENT COSTS
      CALL SPTEQ (SECOST,ANNSE,UP,QTY,QPA)
C CALCULATE ANNUAL COSTS
      ANNLSC=ALSCOH*QPA*QTY*12.*OPHR*UF
      ANNTRN=ATRNOH*QPA*QTY*12.*OPHR*UF
C CALCULATE TOTAL COSTS
      ANNTOT=ANNLSC+ANNTRN+ANNSE
      TNCOST=TNCOST+TSPAR+SECOST
      TRCOST=TRCOST+ANNTOT
C     PLACING ANNUALIZED COSTS IN ARRAYS FOR PRINTING PURPOSES
      ALSC(J)=ANNLSC
      ATRN(J)=ANNTRN
      ANSE(J)=ANNSE
      ATOT(J)=ANNTOT
      TOTSP(J)=TSPAR
      ASECST(J)=SECOST
C     CALCULATE FIGURES OF MERIT TOTALS
C     ASSUME SERIES COMBINATION FOR OVERALL SUBSYSTEM MTBF AND MTBMA
      TOTLSC=TOTLSC+ALSCOH
      TOTFLD=TOTFLD+ALFDOH
      TOTDEP=TOTDEP+DEPREP
      TOTTRN=TOTTRN+ATRNOH
      STMTBF=1./AMTHF+STMTBF
      TOMTBF=1./STMTBF
      SMTBMA=1./AMTBMA+SMTBMA
      TMTBMA=1./SMTBMA
      TMMHOH=TMMHOH+AMHTOH
      UMMHOH=UMMHOH+AMUNOH
      SMMHOH=SMMHOH+AMSHOH
      IF(CERSET.EQ.2) GO TO 340
      WRITE(IOUT,5001)J,CD,SPARS,ALSCOH,ATRNOH,AMTBF,AMTBMA,AMHTOH,
     $ ANRTS,ANNLSC,ANNTRN,ANNSE,ANNTOT,TSPAR,SECOST
 5001 FORMAT(1X,I2,")",F6.2,F8.1," ** ",2F8.3,2F8.0,2F8.4,6F10.0)
```

```
      GO TO 300
  340 CONTINUE
      IF(CKNRTS.EQ.0) GO TO 343
      ALFDOH=LFONRT
      AMHTOH=TMHNRT
      AMSHOH=SHPNRT
  343 WRITE(IOUT,6004)J,CD,SPARS,ALSCOH,ALFDOH,DEPREP,ATRNOH,AMTBF,
     $ AMTBMA,AMHTOH,AMUNOH,AMSHOH,ANRTS
 6004 FORMAT(//1X,I2,")",F6.2,F8.1," ** ",2(F8.3,2X),F6.0,2X,F8.3,
     $  2(2X,F8.0),4(2X,F8.4))
  300 CONTINUE
      IF (CEHSET.EQ.1) GO TO 302
      WRITE(IOUT,6005)
 6005 FORMAT  (21X,2("---------",1X),"-------",6(1X,"---------"))
      WRITE(IOUT,6006)TOTLSC,TOTFLD,TOTDEP,TOTTRN,TOMTBF,TMTBMA,TMMHOH,
     $ UMMHOH,SMMHOH
 6006 FORMAT(//2X,"SUBSYSTEM TOTALS = ",2(F9.3,1X),F7.0,1X,F9.3,
     $2(1X,F9.0),3(1X,F9.4))
      WRITE(IOUT,6007)
 6007 FORMAT(////17X,3("ANNUAL",10X),"TOTAL",10X,"SPARES",12X,"SE"/18X,
     $ "LSC",11X,"TNG COST",8X,"SE COST",8X,"ANN. COST",9X,"COST",12X,
     $ "COST")
      DO 301 J=1,N
      WRITE(IOUT,6008)J,ALSC(J),ATRN(J),ANSE(J),ATOT(J),TOTSP(J),
     $ASECST(J)
 6008 FORMAT (/8X,I2,")",5X,F8.0,3(8X,F8.0),7X,F8.0,8X,F8.0)
  301 CONTINUE
C PRINT TOTAL COST FOR THIS ALTERNATIVE
  302 CONTINUE
      WRITE (IOUT,5002) I,TRCOST,I,TNCOST
 5002 FORMAT(///40X,"TOTAL ANNUAL COST FOR ALTERNATIVE ",I1,7X," =",F10.
     +0/40X,"TOTAL NON-RECURRING COST FOR ALTERNATIVE ",I1," =",F10.0)
  900 CONTINUE
C********* CHECK FOR CONTINUATION OF RUN FOR NEW SYSTEM ***************
      READ (IIN,1900) KEY
      IF (EOF(IIN)) 950,920
 1900 FORMAT (A1)
  920 IF (KEY.EQ."C") GO TO 60
  950 CONTINUE
      STOP
      END
```

CARD NR.	SEVERITY	DETAILS	DIAGNOSIS OF PROBLEM
125	I		AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
164	I		AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.

SYMBOLIC REFERENCE MAP (R=1)

PROGRAM ALP33

ENTRY POINTS
4114 ALP33

VARIABLES SN		TYPE		RELOCATION	SN		TYPE		RELOCATION
25	A	REAL	ARRAY	BLK	6264	AA	REAL		
6263	AC	REAL			1	ACSON	REAL		SP1
11	ALFOOH	REAL		NVAR	6163	ALSC	REAL	ARRAY	
24	ALSCOM	REAL		IVAR	6052	ALT	INTEGER		
25	AMHTOH	REAL		IVAR	14	AMSHOH	REAL		NVAR
22	AMTBF	REAL		IVAR	23	AMTBMA	REAL		IVAR
13	AMUNOH	REAL		NVAR	0	ANAME	REAL	ARRAY	CVR1
6116	ANNLSC	REAL			6115	ANNSE	REAL		
6122	ANNTOT	REAL			6117	ANNTRN	REAL		
27	ANRTS	REAL		IVAR	6245	ANSE	REAL	ARRAY	
6350	ASECST	REAL	ARRAY		6276	ATOT	REAL	ARRAY	
6214	ATRN	REAL	ARRAY		26	ATRNOH	REAL		IVAR
6125	AXP	REAL	ARRAY		20	BF	REAL		IVAR
23	BLANK	REAL		BLK	7	CC	REAL		IVAR
10	CD	REAL		IVAR	6054	CERSET	INTEGER		
6055	CKNRTS	INTEGER			6062	CM	REAL		
6156	CTE	REAL	ARRAY		12	DEPREP	REAL		NVAR
0	ENRTS	REAL		WNRT	4	EXPAND	REAL	ARRAY	BLK
12	FAN	REAL		IVAR	11	FDI	REAL		IVAR
13	FEM	REAL		IVAR	0	FNRTS	INTEGER		NVAR
14	FPS	REAL		IVAR	16	FSS	REAL		IVAR
15	FXR	REAL		IVAR	6133	HDG	REAL	ARRAY	
6065	I	INTEGER			6	IBMCOM	REAL		NVAR
4	IBMNAV	REAL		NVAR	5	IBMSEN	REAL		NVAR
2	IBOM	INTEGER		IVAR	3	ICAR	INTEGER		IVAR
1	ICOM	INTEGER		IVAR	10	ICRCOM	REAL		NVAR
7	ICRNAV	REAL		NVAR	6110	ID	INTEGER		
3	IFGCOM	REAL		NVAR	1	IFGNAV	REAL		NVAR
2	IFGSEN	REAL		NVAR	6070	IFIG	INTEGER		
6056	IIN	INTEGER			6066	INAV	INTEGER		
6057	IOUT	INTEGER			6060	IPAGE	INTEGER		
0	ISEN	INTEGER		IVAR	6067	J	INTEGER		
6071	K	INTEGER			6061	KEY	INTEGER		
0	KEYL	INTEGER	ARRAY	BLK	0	LFDNRT	REAL		VNRT
6072	N	INTEGER			6121	NLPA	INTEGER	ARRAY	
0	OPHR	REAL		SP1	17	PD	REAL		IVAR
6111	QPA	REAL			6053	QTY	INTEGER		
6114	SECOST	REAL			2	SHPNRT	REAL		VNRT
6107	SMMHOH	REAL			6103	SMTBMA	REAL		
6112	SPARS	REAL			24	STAR	REAL		BLK
6101	STMTBF	REAL			1	TMHNRT	REAL		VNRT
6105	TMMHOH	REAL			6104	TMTBMA	REAL		
6074	TNCOST	REAL			6102	TOMTBF	REAL		
6077	TOTDEP	REAL			6076	TOTFLD	REAL		
6075	TOTLSC	REAL			6327	TOTSP	REAL	ARRAY	
6100	TOTTRN	REAL			6073	TRCOST	REAL		
6113	TSPAR	REAL			21	UF	REAL		IVAR
6106	UMMHOH	REAL			4	UP	REAL		IVAR
5	V	REAL		IVAR	6	W	REAL		IVAR

FILE NAMES MODE
0 INPUT 2043 OUTPUT 0 TAPE5 2043 TAPE6

```
EXTERNALS          TYPE   ARGS
         COVER             1                         EOF        REAL       1
         ESTIM             0                         ESTIM2                0
         ESTLFDN           0                         ESTLFD2               0
         ESTMMHN           0                         ESTMMH2               0
         ESTMSHN           0                         ESTMSH2               0
         ESTNRT            0                         ESTNRT2               0
         PRINT1            3                         SPARES                8
         SPTEQ             5

STATEMENT LABELS
 4315  10                          4326  20                          4340  30
 4127  50                          4131  60                          4140  100
 4145  110                         4154  130                            0  140
 4200  150                         4210  160                            0  165
 4220  170                            0  175                         4232  180
 4240  190                            0  200                         4255  210
 4266  220                         4273  230                         4300  240
 4304  250                         4356  251                         4366  252
 4400  253                         4403  254                         4405  255
    0  260      INACTIVE              0  261      INACTIVE           4417  270
    0  275      INACTIVE           4434  276                         4436  277
 4472  280                         4646  300                            0  301
 4700  302                            0  313      INACTIVE           4505  314
 4536  315                         4541  316                         4556  317
 4533  319                         4637  340                         4644  343
 4702  900                         4711  920                         4713  950
 5003  1000   FMT                  5137  1001   FMT                  5376  1100   FMT
 4747  1110   FMT                  4754  1120   FMT                  5573  1200   FMT
 6031  1900   FMT                  5014  2000   FMT                  5026  2100   FMT
 5043  2200   FMT                  5062  2300   FMT                  5112  2400   FMT
 5125  2500   FMT                  5160  2600   FMT                  5224  2610   FMT
 5235  2620   FMT                  5246  2630   FMT                  5256  2635   FMT
 5270  2636   FMT                  5304  2637   FMT                  5322  2638   FMT
 5334  2639   FMT                  5345  2640   FMT                  5360  2641   FMT
 5404  2700   FMT                  5424  2800   FMT                  5435  2900   FMT
 5605  3000   FMT                  5637  5001   FMT                  6006  5002   FMT
 5447  6000   FMT                  4446  6001                        5506  6002   FMT
 4453  6003                        5666  6004   FMT                  5702  6025   FMT
 5725  6006   FMT                  5740  6007   FMT                  5771  6008   FMT
 5544  6035   FMT

LOOPS  LABEL    INDEX    FROM-TO    LENGTH    PROPERTIES
 4146  130     * I        88  94      11B               EXT REFS
 4164  140     * I       107 109       5B      INSTACK    EXITS
 4213  165       J       127 128       3B      INSTACK
 4223  175       J       132 133       3B      INSTACK
 4243  200     * I       149 151       5B      INSTACK    EXITS
 4406  900     * I       245 432     277B               EXT REFS    EXITS    NOT INNER
 4463  300     * J       310 410     166B               EXT REFS    EXITS
 4661  301     * J       422 426      17B               EXT REFS

COMMON BLOCKS   LENGTH
         BLK        27
         CVR1        2
         IVAR       24
         SP1         2
```

```
COMMON BLOCKS   LENGTH
      NVAR          13
      WNRT           1
      VNRT           3

STATISTICS
  PROGRAM LENGTH                 2303B     1219
  BUFFER LENGTH                  4106B     2118
  CM LABELED COMMON LENGTH        110B       72
```

```
SUBROUTINE COVER       73/74    OPT=1                    FTN 4.6+433B       79/05/15. 12.28.26          AGE    1

      C*****************************************************************************
      C SUBROUTINE TO PRINT COVER PAGE
            SUBROUTINE COVER (IOUT)
            COMMON / CVR1 / ANAME(2)
            WRITE (IOUT,8000)
       8000 FORMAT("1")
            WRITE (IOUT,6000)
       6000 FORMAT(////////////////////)
      C PRINT TITLE BLOCK
            DO 10 I=1,4
         10 WRITE (IOUT,1000)
       1000 FORMAT(27X,"$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$"
           +,"$$$$$$$$$$$$$$$$$$$$$$$$")
            DO 20 I=1,4
         20 WRITE (IOUT,2000)
       2000 FORMAT(27X,"$$$$",68X,"$$$$")
            WRITE (IOUT,3000)
       3000 FORMAT(27X,"$$$$   A V I O N I C S   L A B O R A T O R Y   ",
           +"P R E D I C T I V E     $$$$")
            WRITE (IOUT,2000)
            WRITE (IOUT,2000)
            WRITE (IOUT,4000)
       4000 FORMAT(27X,"$$$$      O P E R A T I O N S   A N D   S U P P",
           +"O R T   M O D E L      $$$$")
            WRITE (IOUT,2000)
            WRITE (IOUT,2000)
            WRITE (IOUT,5000)
       5000 FORMAT(27X,"$$$$",27X,"( A L P O S ) ",27X,"$$$$")
            WRITE(IOUT,2000)
            WRITE(IOUT,2000)
            WRITE(IOUT,5010)
       5010 FORMAT(27X,"$$$$",25X,"....VERSION 2....",26X,"$$$$")
            DO 30 I=1,4
         30 WRITE (IOUT,2000)
            DO 40 I=1,4
         40 WRITE (IOUT,1000)
            WRITE (IOUT,6000)
      C PRINT TITLE AND DATE
            CALL DATE (ADATE)
            WRITE (IOUT,7000) ANAME,ADATE
       7000 FORMAT(1X,"RUN TITLE: ",2A10,65X,"DATE: ",A10)
            RETURN
            END

    SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  COVER

VARIABLES      SN  TYPE            RELOCATION
  255  ADATE       REAL                              0  ANAME      REAL        ARRAY     CVR1
  254  I           INTEGER                           0  IOUT       INTEGER               F.P.
```

```
      SUBROUTINE COVER      73/74    OPT=1                          FTN 4.6+433B        79/05/15. 12.28.26        PAGE    2

 EXTERNALS          TYPE   ARGS
       DATE                  1

 STATEMENT LABELS
      0  10                                        0  20                                        0  30
      0  40                                      112  1000     FMT                            127  2000     FMT
    138  3000     FMT                            161  4000     FMT                            204  5000     FMT
    223  5010     FMT                            104  6000     FMT                            247  7000     FMT
     77  8000     FMT

 LOOPS  LABEL    INDEX     FROM-TO     LENGTH     PROPERTIES
    12   10       * I       10 11        5B                 EXT REFS
    20   20       * I       14 15        5B                 EXT REFS
    51   30       * I       33 34        5B                 EXT REFS
    57   40       * I       35 36        5B                 EXT REFS

 COMMON BLOCKS   LENGTH
       CVR1         2

 STATISTICS
   PROGRAM LENGTH                 256B       174
   CM LABELED COMMON LENGTH         2B         2
```

```
      C*****************************************************************************
      C SUBROUTINE TO PRINT LRU INPUT DATA WHEN CERSET=1
      C SUBROUTINE TO PRINT LRU INPUT DATA WHEN CERSET=2
            SUBROUTINE PRINT1 (IIN,IOUT,N)
            COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
           $ ICRNAV,ICRCOM
            DIMENSION CTE(5)
            REAL ID
            REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
            INTEGER FNRTS
            IF(FNRTS.EQ.1) GO TO 16
      C     ECHO LRU DATA INPUT
            PRINT (IOUT,1000)
       1000 FORMAT("   IDENT,          UNIT                                COMPTS,    PCT
           +PCT     PCT     PCT     PCT     PCT    POWER     BIT  UTIL.")
            WRITE (IOUT,1100)
       1100 FORMAT("   NUMBER          PRICE   VOLUME   WEIGHT    COUNT    DIG.  AN
           +AL.     E/M      PS     XMTR     SS      DIS.    /FIT FACTOR    QPA"///)
            GO TO 17
         16 PRINT(IOUT,3200)
       3200 FORMAT("   IDENT,          UNIT                                COMPTS,    PCT
           +PCT     PCT     PCT     PCT     PCT    POWER     BIT  UTIL.              P
           $CT")
            WRITE(IOUT,3300)
       3300 FORMAT("   NUMBER          PRICE   VOLUME   WEIGHT    COUNT    DIG.  AN
           +AL.     E/M      PS     XMTR     SS      DIS.    /FIT FACTOR    QPA   NR
           $TS"///)
         17 CONTINUE
            IF (FNRTS.EQ.1) GO TO 18
            DO 10 I=1,N
      C READ LRU INOUT DATA
            READ (IIN,900)  KEY,ID,UP,V,W,CC,(CTE(K),K=1,5), ENRTS,FSS,PD,
           $BF,UF,QPA
            WRITE(IOUT,3100)I,ID,UP,V,W,CC,(CTE(K),K=1,5),FSS,PD,BF,UF,QPA
       3100 FORMAT(1X,I2,")",A5,3X,F8.0,3X,F6.0,3X,F6.1,3X,F6.0,5(3X,F4.0),3X,
           $ F4.0,3X,F6.0,3X,F4.0,3X,F4.2,3X,F4.0)
         10 CONTINUE
            GO TO 19
         18 CONTINUE
            DO 15 I=1,N
            READ (IIN,900)  KEY,ID,UP,V,W,CC,(CTE(K),K=1,5), ENRTS,FSS,PD,
           $BF,UF,QPA
            WRITE(IOUT,3400)I,ID,UP,V,W,CC,(CTE(K),K=1,5),FSS,PD,BF,UF,QPA,
           $ ENRTS
       3400 FORMAT(1X,I2,")",A5,3X,F8.0,3X,F6.0,3X,F6.1,3X,F6.0,5(3X,F4.0),3X,
           $ F4.0,3X,F6.0,3X,F4.0,3X,F4.2,3X,F4.0,3X,F4.0)
         15 CONTINUE
         19 DO 20 I=1,N
         20 BACKSPACE IIN
        900 FORMAT(A2,1X,A5,F8.0,F6.0,F6.1,F6.0,5F4.0,2F4.0,F6.0,F4.0,F4.2,
           $ F4.0)
            RETURN
            END
```

```
SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  PRINT1

VARIABLES      SN   TYPE          RELOCATION
  342  BF           REAL                                 335  CC         REAL
  345  CTE          REAL      ARRAY                      337  ENRTS      REAL
    0  FNRTS        INTEGER         NVAR                 340  FSS        REAL
  330  I            INTEGER                                6  IRMCOM     REAL         NVAR
    4  IBMNAV       REAL            NVAR                   5  IBMSEN     REAL         NVAR
   10  ICRCOM       REAL            NVAR                   7  ICRNAV     REAL         NVAR
  327  IO           REAL                                   3  IFGCOM     REAL         NVAR
    1  IFGNAV       REAL            NVAR                   2  IFGSEN     REAL         NVAR
    0  IIN          INTEGER           F.P.                 0  IOUT       INTEGER        F.P.
  336  K            INTEGER                              331  KEY        INTEGER
    0  N            INTEGER           F.P.               341  PD         REAL
  344  OPA          REAL                                 343  UF         REAL
  332  UP           REAL                                 333  V          REAL
  334  W            REAL

STATEMENT LABELS
    0  10                        0  15                                       24  16
   30  17                       42  18                                       52  19
    0  20                      317  900      FMT                             64  1000     FMT
  105  1100     FMT            230  3100     FMT                            127  3200     FMT
  151  3300     FMT            303  3400     FMT

LOOPS   LABEL    INDEX    FROM-TO    LENGTH    PROPERTIES
   33   10       * I      30 37      7B                  EXT REFS
   43   15       * I      40 47      7B                  EXT REFS
   53   20       * I      40 49      5B                  EXT REFS

COMMON BLOCKS     LENGTH
       NVAR         0

STATISTICS
  PROGRAM LENGTH                362B       242
  CM LABELED COMMON LENGTH      11B          9
```

```
C*******************************************************************************
C SUBROUTINE TO PREDICT LOGISTICS SUPPORT COST FACTORS BASED ON
C REGRESSION COEFFICENTS
      SUBROUTINE ESTIM
      COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
     +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOM,AMHTOM,ATRNOM,ANRTS
C********* CALCULATE COMPONENTS DENSITY ***********************************
      CD = CC / V
C********* CALCULATE MTBF (BASED ON OPERATING HOURS)********************
      CALL ESTMTF
C********* CALCULATE MTBMA (BASED ON OPERATING HOURS) **************************
      CALL ESTMTA
C********* CALCULATE TOTAL LOGISTICS SUPPORT COST PER OPERATING HOUR*****
      CALL ESTLSC
C********* CALCULATE TOTAL MAINTENANCE MANHOURS (O+I) PER OPERATING HOUR
      CALL ESTMMH
C********* CALCULATE TRAINING COSTS PER OPERATING HOUR ******************
      CALL ESTTRN
      RETURN
      END
```

```
SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1  ESTIM

VARIABLES     SN  TYPE          RELOCATION
   24  ALSCOM     REAL              IVAR       25  AMHTOM    REAL              IVAR
   22  AMTBF      REAL              IVAR       23  AMTBMA    REAL              IVAR
   27  ANRTS      REAL              IVAR       26  ATRNOM    REAL              IVAR
   20  BF         REAL              IVAR        7  CC        REAL              IVAR
   10  CD         REAL              IVAR       12  FAN       REAL              IVAR
   11  FDI        REAL              IVAR       13  FEM       REAL              IVAR
   14  FPS        REAL              IVAR       16  FSS       REAL              IVAR
   15  FXR        REAL              IVAR        2  IBOM      INTEGER           IVAR
    3  ICAR       INTEGER           IVAR        1  ICOM      INTEGER           IVAR
    0  ISEN       INTEGER           IVAR       17  PD        REAL              IVAR
   21  UF         REAL              IVAR        4  UP        REAL              IVAR
    5  V          REAL              IVAR        6  W         REAL              IVAR

EXTERNALS          TYPE    ARGS
       ESTLSC                0                      ESTMMH             0
       ESTMTA                0                      ESTMTF             0
       ESTTRN                0

COMMON BLOCKS    LENGTH
       IVAR         24

STATISTICS
  PROGRAM LENGTH                  12B       10
  CM LABELED COMMON LENGTH        30B       24
```

```
SUBROUTINE ESTMTF      73/74   OPT=1                                    FTN 4.6+433B        79/05/15. 12.28.26        PAGE     1

          C*****************************************************************************
          C SUBROUTINE TO PREDICT MTBF (BASED ON OPERATING HOURS)
                SUBROUTINE ESTMTF
                COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
               +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
          C CALCULATE INDICATOR VARIABLES
                X1M=IBOM-0.274
                X3M=ISEN-0.258
                X4M=ICOM-0.210
                X5 =X1M*X3M
                X6 =X1M*X4M
          C CALCULATE TERMS OF REGRESSION EQUATION
                V0 = 1.36551E+01
                V1 = 3.46281E-01 * X3M
                V2 =-4.58243E-01 * X4M
                V3 = 1.15374E+00 * X5
                V4 = 6.34763E-01 * X6
                V5 = 1.72434E-02 * FEM
                V6 = 3.79188E-04 * (V-1484.0)
                V7 = 9.88045E-03 * (FSS-61.0)
                V8 =-6.18897E-08 * (V-3337.0)**2
                V9 = 2.09706E-04 * (FDI-43.08)**2
                V10= 1.88349E-04 * (FSS-52.21)**2
                V11=-5.82664E-04 * (BF-27.39)**2
                V12=-2.38566E-01 * ALOG(UP)
                V13=-6.25055E-01 * ALOG(V)
                V14=-4.60890E-01 * ALOG(W)
                ALNMTF=V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
               +V11 + V12 + V13 + V14
                AMTBF=EXP(ALNMTF)
                RETURN
                END


   SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1  ESTMTF

VARIABLES        SN  TYPE           RELOCATION
  155  ALNMTF        REAL                              24  ALSCOH     REAL              IVAR
   25  AMHTOH        REAL           IVAR               22  AMTBF      REAL              IVAR
   23  AMTBMA        REAL           IVAR               27  ANRTS      REAL              IVAR
   26  ATRNOH        REAL           IVAR               20  BF         REAL              IVAR
    7  CC            REAL           IVAR               10  CD         REAL              IVAR
   12  FAN           REAL           IVAR               11  FDI        REAL              IVAR
   13  FEM           REAL           IVAR               14  FPS        REAL              IVAR
   16  FSS           REAL           IVAR               15  FXR        REAL              IVAR
    2  IBOM          INTEGER        IVAR                3  ICAR       INTEGER           IVAR
    1  ICOM          INTEGER        IVAR                0  ISEN       INTEGER           IVAR
   17  PD            REAL           IVAR               21  UF         REAL              IVAR
    4  UP            REAL           IVAR                5  V          REAL              IVAR
  136  V0            REAL                             137  V1         REAL
  150  V10           REAL                             151  V11        REAL
```

```
VARIABLES      SN  TYPE           RELOCATION
  152  V12         REAL                               153  V13        REAL
  154  V14         REAL                               140  V2         REAL
  141  V3          REAL                               142  V4         REAL
  143  V5          REAL                               144  V6         REAL
  145  V7          REAL                               146  V8         REAL
  147  V9          REAL                                 6  W          REAL             IVAR
  131  X1M         REAL                               132  X3M        REAL
  133  X4M         REAL                               134  X5         REAL
  135  X6          REAL

EXTERNALS          TYPE    ARGS
      ALOG         REAL       1 LIBRARY                   EXP        REAL       1 LIBRARY

COMMON BLOCKS   LENGTH
      IVAR          24

STATISTICS
   PROGRAM LENGTH                  156B      110
   CM LABELED COMMON LENGTH         30B       24
```

```
      C*******************************************************************************
      C SUBROUTINE TO PREDICT MTBMA (BASED ON OPERATING HOURS
            SUBROUTINE ESTMTA
            COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
           +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOM,AMHTOH,ATRNOH,ANRTS
      C CALCULATE INDICATOR VARIABLES
            X1M=IBOM-0.224
            X3M=ISEN-0.258
            X4M=ICOM-0.210
            X5 =X1M*X3M
            X6=X1M*X4M
      C CALCULATE TERMS OF REGRESSION EQUATION
            V0 = 9.85866E+00
            V1 = 3.15528E-01 * X3M
            V2 =-3.13506E-01 * X4M
            V3 = 1.45371E+00 * X5
            V4 = 8.31176E-01 * X6
            V5 = 1.17666E-02 * W
            V6 = 8.26669E-05 * CC
            V7 = 1.76838E-02 * FEM
            V8 = 6.50037E-03 * (FSS-61.0)
            V9 = 1.86436E-04 * (FSS-52.21)**2
            V10= 7.32661E-07 * (PD-729.0)**2
            V11=-4.83934E-04 * (BF-27.39)**2
            V12=-2.83805E-01 * ALOG(UP)
            V13=-8.39866E-01 * ALOG(W)
              ALNMTA=V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
           +V11 + V12 + V13
            AMTBMA=EXP(ALNMTA)
            RETURN
            END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTMTA

VARIABLES		SN TYPE	RELOCATION				
142	ALNMTA	REAL		24	ALSCOM	REAL	IVAR
25	AMHTOH	REAL	IVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR
7	CC	REAL	IVAR	10	CD	REAL	IVAR
12	FAN	REAL	IVAR	11	FDI	REAL	IVAR
13	FEM	REAL	IVAR	14	FPS	REAL	IVAR
16	FSS	REAL	IVAR	15	FXR	REAL	IVAR
2	IBOM	INTEGER	IVAR	3	ICAR	INTEGER	IVAR
1	ICOM	INTEGER	IVAR	0	ISEN	INTEGER	IVAR
17	PD	REAL	IVAR	21	UF	REAL	IVAR
4	UP	REAL	IVAR	5	V	REAL	IVAR
124	V0	REAL		125	V1	REAL	
136	V10	REAL		137	V11	REAL	
140	V12	REAL		141	V13	REAL	

```
VARIABLES       SN  TYPE            RELOCATION
  126  V2           REAL                               127  V3          REAL
  130  V4           REAL                               131  V5          REAL
  132  V6           REAL                               133  V7          REAL
  134  V8           REAL                               135  V9          REAL
    6  W            REAL                 IVAR          117  X1M         REAL
  120  X3M          REAL                               121  X4M         REAL
  122  X5           REAL                               123  X6          REAL

EXTERNALS               TYPE    ARGS
       ALOG         REAL          1 LIBRARY                EXP          REAL          1 LIBRARY

COMMON BLOCKS     LENGTH
       IVAR           24

STATISTICS
  PROGRAM LENGTH                 143B      99
  CM LABELED COMMON LENGTH        30B      24
```

```
C*****************************************************************************
C SUBROUTINE TO PREDICT LOGISTICS SUPPORT COST PER OPERATING HOUR
      SUBROUTINE ESTLSC
      COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
     +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
C CALCULATE INDICATOR VARIABLES
      X1M=IBOM-0.286
      X2M=ICAR-0.270
      X3M=ISEN-0.254
      X4M=ICOM-0.206
      X5 =X1M*X3M
      X6 =X1M*X4M
      X7 =X2M*X4M
C CALCULATE TERMS OF REGRESSION EQUATION
      V0 =-8.15108E+00
      V1 = 3.86111E+00 * X1M
      V2 = 3.66533E+00 * X2M
      V3 =-4.85271E-01 * X3M
      V4 =-2.56663E+00 * X5
      V5 =-1.66262E+00 * X6
      V6 =-7.67253E-01 * X7
      V7 = 1.27356E-02 * FPS
      V8 = 2.25967E-02 * (FAN-63.3)
      V9 =-7.42999E-03 * (FSS-61.1)
      V10= 2.38503E+00 * (UF-1.64)
      V11=-9.20384E-11 * (UP-133606.0)**2
      V12=-1.52864E-04 * (W-64.3)**2
      V13=-1.07105E-03 * (FAN-48.8)**2
      V14= 1.20418E-03 * (FEM-47.0)**2
      V15= 7.10025E-04 * (FXR-40.2)**2
      V16=-1.61651E-04 * (FSS-51.85)**2
      V17=-1.11568E-06 * (PD-722.0)**2
      V18= 5.00996E+00 * (UF-1.682)**2
      V19= 1.70042E-03 * (BF-27.26)**2
      V20= 4.60293E-01 * ALOG(UP)
      V21= 2.35583E-01 * ALOG(V)
      ALNLSC=V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
     *V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20 + V21
      ALSCOH=EXP(ALNLSC)
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1 ESTLSC

VARIABLES

SN	NAME	TYPE	RELOCATION	SN	NAME	TYPE	RELOCATION
244	ALNLSC	REAL		24	ALSCOH	REAL	IVAR
25	AMHTOH	REAL	IVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR
7	CC	REAL	IVAR	10	CD	REAL	IVAR

```
VARIABLES      SN  TYPE           RELOCATION
    12  FAN        REAL                 IVAR          11  FDI       REAL              IVAR
    13  FEM        REAL                 IVAR          14  FPS       REAL              IVAR
    16  FSS        REAL                 IVAR          15  FXR       REAL              IVAR
     2  IBOM       INTEGER              IVAR           3  ICAR      INTEGER           IVAR
     1  ICOM       INTEGER              IVAR           0  ISEN      INTEGER           IVAR
    17  PD         REAL                 IVAR          21  UF        REAL              IVAR
     4  UP         REAL                 IVAR           5  V         REAL              IVAR
   216  V0         REAL                              217  V1        REAL
   230  V10        REAL                              231  V11       REAL
   232  V12        REAL                              233  V13       REAL
   234  V14        REAL                              235  V15       REAL
   236  V16        REAL                              237  V17       REAL
   240  V18        REAL                              241  V19       REAL
   220  V2         REAL                              242  V20       REAL
   243  V21        REAL                              221  V3        REAL
   222  V4         REAL                              223  V5        REAL
   224  V6         REAL                              225  V7        REAL
   226  V8         REAL                              227  V9        REAL
     6  W          REAL                 IVAR         207  X1M       REAL
   210  X2M        REAL                              211  X3M       REAL
   212  X4M        REAL                              213  X5        REAL
   214  X6         REAL                              215  X7        REAL

EXTERNALS           TYPE    ARGS
        ALOG        REAL      1 LIBRARY                    EXP       REAL         1 LIBRARY

COMMON BLOCKS    LENGTH
        IVAR         24

STATISTICS
  PROGRAM LENGTH                245B     165
  CM LABELED COMMON LENGTH       30B      24
```

```
      C******************************************************************************
      C SUBROUTINE TO PREDICT TOTAL MAINTENANCE MANHOURS (O + I) PER
      C OPERATING HOUR
            SUBROUTINE ESTMMH
            COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
           +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOM,AMHTOH,ATRNOH,ANRTS
      C CALCULATE INDICATOR VARIABLES
            X1M=IBOM-0.286
            X2M=ICAR-0.254
            X3M=ISEN-0.254
            X4M=ICOM-0.190
            X5 =X1M*X3M
            X6 =X1M*X4M
            X7 =X2M*X4M
      C CALCULATE TERMS OF REGRESSION EQUATION
            V0 =-1.95115E-01
            V1 =-4.51221E-02 * X5
            V2 =-7.74745E-02 * X6
            V3 =-6.49036E-02 * X7
            V4 = 1.62292E-03 * FDI
            V5 =-3.34605E-04 * FSS
            V6 =-6.61350E-05 * (V-1438.0)
            V7 = 4.62871E-03 * (W-35.0)
            V8 = 1.87208E-03 * (FAN-62.7)
            V9 = 1.20082E-03 * (FEM-16.0)
            V10= 1.54368E-03 * (FPS-3.43)
            V11= 1.24928E-03 * (BF-4.83)
            V12= 1.70110E-08 * (V-3307.0)**2
            V13=-1.29283E-05 * (W-64.4)**2
            V14=-3.33581E-05 * (FAN-49.2)**2
            V15= 3.56802E-05 * (FEM-46.4)**2
            V16=-8.38687E-05 * (FPS-49.83)**2
            V17= 5.78168E-05 * (BF-26.93)**2
            V18= 7.47867E-02 * ALOG(V)
            V19=-4.98197E-02 * ALOG(W)
            AMHTOH=V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
           +V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19
            RETURN
            END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTMMH

VARIABLES SN		TYPE	RELOCATION				
24	ALSCOM	REAL	IVAR	25	AMHTOH	REAL	IVAR
22	AMTBF	REAL	IVAR	23	AMTBMA	REAL	IVAR
27	ANRTS	REAL	IVAR	26	ATRNOH	REAL	IVAR
20	BF	REAL	IVAR	7	CC	REAL	IVAR
10	CD	REAL	IVAR	12	FAN	REAL	IVAR
11	FDI	REAL	IVAR	13	FEM	REAL	IVAR
14	FPS	REAL	IVAR	16	FSS	REAL	IVAR

```
VARIABLES      SN  TYPE            RELOCATION
    15  FXR        REAL                IVAR              2  IBOM     INTEGER             IVAR
     3  ICAR       INTEGER             IVAR              1  ICOM     INTEGER             IVAR
     0  ISEN       INTEGER             IVAR             17  PD       REAL                IVAR
    21  UF         REAL                IVAR              4  UP       REAL                IVAR
     5  V          REAL                IVAR            205  V0       REAL
   206  V1         REAL                                217  V10      REAL
   220  V11        REAL                                221  V12      REAL
   222  V13        REAL                                223  V14      REAL
   224  V15        REAL                                225  V16      REAL
   226  V17        REAL                                227  V18      REAL
   230  V19        REAL                                207  V2       REAL
   210  V3         REAL                                211  V4       REAL
   212  V5         REAL                                213  V6       REAL
   214  V7         REAL                                215  V8       REAL
   216  V9         REAL                                  6  W        REAL                IVAR
   176  X1M        REAL                                177  X2M      REAL
   200  X3M        REAL                                201  X4M      REAL
   202  X5         REAL                                203  X6       REAL
   204  X7         REAL

EXTERNALS          TYPE    ARGS
      ALOG         REAL       1 LIBRARY

COMMON BLOCKS    LENGTH
      IVAR           24

STATISTICS
  PROGRAM LENGTH                 231B     153
  CM LABELED COMMON LENGTH        30B      24
```

```
      C*****************************************************************************
      C SUBROUTINE TO PREDICT TRAINING COSTS PER OPERATING HOUR
            SUBROUTINE ESTTRN
            COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
           +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
      C CALCULATE INDICATOR VARIABLES
            X1M=IBOM-0.290
            X3M=ISEN-0.258
            X4M=ICOM-0.194
            X5 =X1M*X3M
            X6 =X1M*X4M
      C CALCULATE TERMS OF REGRESSION EQUATION
            V0 = 2.02442E+01
            V1 = 7.47947E-01 * X1M
            V2 =-7.17271E-01 * X3M
            V3 =-1.37065E+00 * X4M
            V4 =-2.24068E+00 * X5
            V5 =-1.38297E+00 * X6
            V6 =-2.25394E-01 * FDI
            V7 =-2.08437E-01 * FAN
            V8 =-2.07642E-01 * FEM
            V9 =-2.18839E-01 * FPS
            V10=-2.04514E-01 * FXR
            V11= 2.38818E-04 * (CC-889.0)
            V12=-3.09409E-04 * (W-64.5)**2
            V13=-1.61411E-07 * (CC-2983.0)**2
            V14=-4.98171E-04 * (FAN-49.2)**2
            V15= 4.94961E-04 * (FEM-46.5)**2
            V16=-1.42849E-03 * (FPS-49.78)**2
            V17=-4.95475E-04 * (FSS-51.98)**2
            V18=-1.39832E-06 * (PD-724.0)**2
            V19= 1.51222E+00 * (UF-1.684)**2
            V20= 1.93953E-03 * (BF-26.94)**2
            V21= 3.64906E-01 * ALOG(UP)
            ALNTRN = V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
           +V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20 + V21
            ATRNOH = EXP(ALNTRN)
            RETURN
            END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTTRN

VARIABLES

SN		TYPE	RELOCATION	SN		TYPE	RELOCATION
227	ALNTRN	REAL		24	ALSCOH	REAL	IVAR
25	AMHTOH	REAL	IVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR
7	CC	REAL	IVAR	10	CD	REAL	IVAR
12	FAN	REAL	IVAR	11	FDI	REAL	IVAR
13	FEM	REAL	IVAR	14	FPS	REAL	IVAR

```
VARIABLES      SN  TYPE             RELOCATION
   16 F3S          REAL                   IVAR          15 FXR      REAL                IVAR
    2 IBOM         INTEGER                IVAR           3 ICAR     INTEGER             IVAR
    1 ICOM         INTEGER                IVAR           0 ISEN     INTEGER             IVAR
   17 PD           REAL                   IVAR          21 UF       REAL                IVAR
    4 UP           REAL                   IVAR           5 V        REAL                IVAR
  201 V0           REAL                                202 V1       REAL
  213 V10          REAL                                214 V11      REAL
  215 V12          REAL                                216 V13      REAL
  217 V14          REAL                                220 V15      REAL
  221 V16          REAL                                222 V17      REAL
  223 V18          REAL                                224 V19      REAL
  203 V2           REAL                                225 V20      REAL
  226 V21          REAL                                204 V3       REAL
  205 V4           REAL                                206 V5       REAL
  207 V6           REAL                                210 V7       REAL
  211 V8           REAL                                212 V9       REAL
    6 W            REAL                   IVAR         174 X1M      REAL
  175 X3M          REAL                                176 X4M      REAL
  177 X5           REAL                                200 X6       REAL

EXTERNALS            TYPE   ARGS
     ALOG          REAL       1 LIBRARY                     EXP      REAL        1 LIBRARY

COMMON BLOCKS   LENGTH
     IVAR          24

STATISTICS
  PROGRAM LENGTH                 230B      152
  CM LABELED COMMON LENGTH        30B       24
```

```
C*******************************************************************************
C SUBROUTINE TO PREDICT NRTS PERCENTAGE
      SUBROUTINE ESTNRT
      COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
     +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
C CALCULATE INDICATOR VARIABLES
      X1M=IBOM-0.274
      X2M=ICAR-0.274
      X3M=ISEN-0.242
      X5 =X1M*X3M
      X5 = X1M * X3M
C CALCULATE TERMS OF REGRESSION EQUATION
      V0 = 2.63934E+02
      V1 = 6.35414E+01 * X1M
      V2 = 4.13039E+01 * X2M
      V3 =-1.45530E+01 * X3M
      V4 = 2.78727E+01 * X5
      V5 =-1.52810E+00 * FPS
      V6 = 1.90808E-02 * (V - 1475.0)
      V7 =-2.84549E+01 * (CD - .938)
      V8 =-1.41696E+00 * (FDI - 7.68)
      V9 =-1.65207E+00 * (FAN - 63.5)
      V10=-3.49197E-01 * (FXR - 11.1)
      V11= 3.11855E+01 * (UF - 1.65)
      V12=-2.91979E-06 * (V - 3321.0) **2
      V13= 3.12925E-06 * (CC - 2961.0) **2
      V14= 3.17105E+00 * (CD - 2.508)**2
      V15=-4.19461E-02 * (FDI - 43.08)**2
      V16= 5.32776E-02 * (FAN - 49.5) **2
      V17=-3.35258E-02 * (FEM - 45.7) **2
      V18=-5.15621E-02 * (FXR - 41.0) **2
      V19= 3.63251E-05 * (PD - 724.0) **2
      V20= 1.04189E+02 * (UF - 1.684)**2
      V21=-9.80056E-02 * (BF - 27.19)**2
      V22= 6.98140E+00 * ALOG(UP)
      V23=-6.34482E+01 * ALOG(V)
      V24= 3.84040E+01 * ALOG(CC)
      V25= 6.03601E+00 * ALOG(PD)
      ANRTS = V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
     +V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20 + V21 +
     +V22 + V23 + V24 + V25
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1 ESTNRT

VARIABLES

SN	TYPE	RELOCATION		SN	TYPE	RELOCATION
24 ALSCOH	REAL	IVAR		25 AMHTOH	REAL	IVAR
22 AMTBF	REAL	IVAR		23 AMTBMA	REAL	IVAR
27 ANRTS	REAL	IVAR		26 ATRNOH	REAL	IVAR

```
VARIABLES         SN  TYPE            RELOCATION
   20   BF            REAL                IVAR              7   CC          REAL              IVAR
   10   CD            REAL                IVAR             12   FAN         REAL              IVAR
   11   FDI           REAL                IVAR             13   FEM         REAL              IVAR
   14   FPS           REAL                IVAR             16   FSS         REAL              IVAR
   15   FXR           REAL                IVAR              2   IBOM        INTEGER           IVAR
    3   ICAR          INTEGER             IVAR              1   ICOM        INTEGER           IVAR
    0   ISEN          INTEGER             IVAR             17   PD          REAL              IVAR
   21   UF            REAL                IVAR              4   UP          REAL              IVAR
    5   V             REAL                IVAR            237   V0          REAL
  240   V1            REAL                                251   V10         REAL
  252   V11           REAL                                253   V12         REAL
  254   V13           REAL                                255   V14         REAL
  256   V15           REAL                                257   V16         REAL
  260   V17           REAL                                261   V18         REAL
  262   V19           REAL                                241   V2          REAL
  263   V20           REAL                                264   V21         REAL
  265   V22           REAL                                266   V23         REAL
  267   V24           REAL                                270   V25         REAL
  242   V3            REAL                                243   V4          REAL
  244   V5            REAL                                245   V6          REAL
  246   V7            REAL                                247   V8          REAL
  250   V9            REAL                                  6   W           REAL              IVAR
  233   X1M           REAL                                234   X2M         REAL
  235   X3M           REAL                                236   X5          REAL

EXTERNALS          TYPE    ARGS
      ALOG         REAL       1 LIBRARY

COMMON BLOCKS    LENGTH
      IVAR           24

STATISTICS
  PROGRAM LENGTH                  271B      185
  CM LABELED COMMON LENGTH         30B       24
```

```
SUBROUTINE SPTEQ       73/74    OPT=1                         FTN 4.6+433B        79/05/15. 12.28.26        PAGE     1

          C***********************************************************************
          C SUBROUTINE TO CALCULATE SUPPORT EQUIPMENT COSTS
                SUBROUTINE SPTEQ (SECOST,ANNSE,UC,QTY,QPA)
                INTEGER QTY
          C CALCULATE INITIAL SUPPORT EQUIPMENT COSTS
                SECOST=.36*UC*QTY*QPA
          C CALCULATE ANNUAL RECURRING SUPPORT EQUIPMENT COST
                ANNSE=.1*SECOST
                RETURN
                END

    SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  SPTEQ

VARIABLES        SN  TYPE              RELOCATION
     0  ANNSE        REAL                  F.P.          0  QPA       REAL                  F.P.
     0  QTY          INTEGER               F.P.          0  SECOST    REAL                  F.P.
     0  UC           REAL                  F.P.

STATISTICS
  PROGRAM LENGTH                   16B      14
```

```
C*****************************************************************************
C SPARES SUBROUTINE FOR ALPOS MODEL
      SUBROUTINE SPARES (MTBMA,NOSYS,QPA,UC,TSPARE,CSPARE,NRTS,IOUT)
      COMMON /SP1/ OPHR,ACSQN
      REAL MTBMA,NOSQN,NRTS,LAMTS,LAMTD
C CONSTANTS PER AFLC LSC MODEL AND GUIDE
      BRCT=.33
      DRCT=1.84
      OST=.5
      EBO=.1
C CALCULATE SPARES FACTORS
C  NUMBER OF SQUADRONS
      NOSQN=FLOAT(NOSYS)/ACSQN
      NOSQN=IFIX(NOSQN)
C  MONTHLY FAILURE RATE
      FSITE=(OPHR*ACSQN*QPA)/MTBMA
      FDEPOT=(OPHR*FLOAT(NOSYS)*QPA)/MTBMA
C FAILURES TO BE SPARED FOR
      LAMTS=FSITE*((1.-NRTS)*BRCT+NRTS*OST)
      LAMTD=FDEPOT*(NRTS*DRCT)
C CALCULATE SPARES
      CALL EBOS (LAMTS,EBO,XSITE)
      CALL EBOS (LAMTD,EBO,XDEP)
      TSPARE=(XDEP+NOSQN*XSITE)
C CALCULATE SPARES COST
      CSPARE=UC*TSPARE
      RETURN
      END
```

```
     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    3  SPARES

VARIABLES      SN  TYPE          RELOCATION
    1  ACSQN       REAL             SP1            62  BRCT      REAL
    0  CSPARE      REAL               F.P.         63  DRCT      REAL
   65  EBO         REAL                            67  FDEPOT    REAL
   66  FSITE       REAL                             0  IOUT      INTEGER   *UNUSED    F.P.
   61  LAMTD       REAL                            60  LAMTS     REAL
    0  MTBMA       REAL               F.P.         57  NOSQN     REAL
    0  NOSYS       INTEGER            F.P.          0  NRTS      REAL                 F.P.
    0  OPHR        REAL             SP1            64  OST       REAL
    0  QPA         REAL               F.P.          0  TSPARE    REAL                 F.P.
    0  UC          REAL               F.P.         71  XDEP      REAL
   70  XSITE       REAL

EXTERNALS          TYPE    ARGS
     EBOS                    3

INLINE FUNCTIONS   TYPE    ARGS
     FLOAT         REAL      1  INTRIN                  IFIX      INTEGER    1  INTRIN
```

```
COMMON BLOCKS   LENGTH
     SP1           2

STATISTICS
  PROGRAM LENGTH                 72B        58
  CM LABELED COMMON LENGTH        2B         2
```

```
      C*************************************************************************************
      C SUBROUTINE TO CALCULATE REQUIRED SPARES QUANTITIES BASED ON EBOS
            SUBROUTINE EBOS (DEMAND,EBO,X)
      C INITIALIZE VARIABLES
            X=0.
            CUMPRO=0.
            XBO=DEMAND
            PROB=EXP(-DEMAND)
      C CALCULATE CUMULATIVE BACK ORDERS
          1 IF (XBO.LE.EBO) GO TO 2
            CUMPRO=CUMPRO+PROB
            XBO=XBO-1.+CUMPRO
            X=X+1.
            PROB=PROB*DEMAND/X
            GO TO 1
          2 RETURN
            END
```

```
     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
   3  EBOS

VARIABLES      SN  TYPE          RELOCATION
  26  CUMPRO       REAL                           0  DEMAND    REAL           F.P.
   0  EBO          REAL               F.P.       30  PROB      REAL
   0  X            REAL               F.P.       27  XBO       REAL

EXTERNALS          TYPE    ARGS
     EXP           REAL      1 LIBRARY

STATEMENT LABELS
  12  1                              24  2

STATISTICS
  PROGRAM LENGTH               31B      25
```

AD-A078 052 WESTINGHOUSE ELECTRIC CORP HUNT VALLEY MD F/G 14/1
PREDICTIVE OPERATIONS AND MAINTENANCE COST MODEL. VOLUME I.(U)
AUG 79 E L WIENECKE, E E FELTUS F33615-77-C-1105
UNCLASSIFIED AFAL-TR-79-1120-VOL-1 NL

3 OF 3
AD
A078052

END
DATE
FILMED
1 -80
DDC

```
C*****************************************************************************
C SUBROUTINE TO PREDICT LOGISTICS SUPPORT COST FACTORS BASED ON
C REGRESSION COEFFICENTS AND PER'S DEVELOPED IN PHASE 2
      SUBROUTINE ESTIM2
      COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
     +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
      COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
     $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
C******** CALCULATE COMPONENTS DENSITY ***********************************
      CD = CC / V
C ******** CALCULATE MTBF (BASED ON OPERATING HOURS)*****************
      CALL ESTMTF2
C ******** CALCULATE MTBMA (BASED ON OPERATING HOURS)****************
      CALL ESTMTA2
C ******** CALCULATE TOTAL LOGISTICS SUPPORT COST PER OPERATING HOUR
      CALL ESTLSC2
C ******** CALCULATE STANDARD COST OF DEPOT REPAIR*******************
      CALL ESTDEP2
C ******** CALCULATE UNSCHEDULED MAINTENANCE MANHOURS PER OPERATING HOUR
      CALL ESTMUN2
C ******** CALCULATE TRAINING COSTS PER OPERATING HOUR***************
      CALL ESTTRN2
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTIM2

VARIABLES

SN	VARIABLE	TYPE	RELOCATION	SN	VARIABLE	TYPE	RELOCATION
11	ALFDOH	REAL	NVAR	24	ALSCOH	REAL	IVAR
25	AMHTOH	REAL	IVAR	14	AMSHOH	REAL	NVAR
22	AMTBF	REAL	IVAR	23	AMTBMA	REAL	IVAR
1:	AMUNOH	REAL	NVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR
7	CC	REAL	IVAR	10	CD	REAL	IVAR
12	DEPREP	REAL	NVAR	12	FAN	REAL	IVAR
11	FDI	REAL	IVAR	13	FEM	REAL	IVAR
0	FNRTS	REAL	NVAR	14	FPS	REAL	IVAR
16	FSS	REAL	IVAR	15	FXR	REAL	IVAR
6	IBMCOM	INTEGER	NVAR	4	IBMNAV	INTEGER	NVAR
5	IBMSEN	INTEGER	NVAR	2	IBOM	INTEGER	IVAR
3	ICAR	INTEGER	IVAR	1	ICOM	INTEGER	IVAR
10	ICRCOM	INTEGER	NVAR	7	ICRNAV	INTEGER	NVAR
3	IFGCOM	INTEGER	NVAR	1	IFGNAV	INTEGER	NVAR
2	IFGSEN	INTEGER	NVAR	0	ISEN	INTEGER	IVAR
17	PD	REAL	IVAR	21	UF	REAL	IVAR
4	UP	REAL	IVAR	5	V	REAL	IVAR
6	W	REAL	IVAR				

```
EXTERNALS           TYPE    ARGS
    ESTDEP2                  0                              ESTLSC2          0
    ESTMTA2                  0                              ESTMTF2          0
    ESTMUN2                  0                              ESTTRN2          0

COMMON BLOCKS   LENGTH
    IVAR           24
    NVAR           13

STATISTICS
  PROGRAM LENGTH                  13B       11
  CM LABELED COMMON LENGTH        45B       37
```

```
      C*************************************************************************
      C SUBROUTINE TO PREDICT MTBF (BASED ON OPERATING HOURS)
      C USING THE PER'S DEVELOPED IN PHASE 2
            SUBROUTINE ESTMTF2
            COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
           +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
            COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
           $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
            REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
      C     CALCULATE TERMS OF THE REGRESSION EQUATION
            V0 = 1,57973E+01
            V1 =-7,76648E-01 * IFGCOM
            V2 =-1,17318E+00 * IBMNAV
            V3 =-1,20762E+00 * IBMCOM
            V4 =-5,66108E-01 * ICRNAV
            V5 =-1,19562E+00 * ICRCOM
            V6 =-3,67444E-06 * UP
            V7 =-2,22840E-01 * CD
            V8 = 1,01840E-02 * FDI
            V9 = 1,83455E-02 * FEM
            V10= 5,99593E-04 * (V-1281,0)
            V11=-1,05527E-02 * (W-31,2)
            V12= 1,32783E-02 * (FSS-79,0)
            V13=-3,05610E-01 * (UF-1,73)
            V14=-1,05947E-07 * (V-3226,0)**2
            V15= 1,27935E-04 * (W-65,3)**2
            V16= 2,21959E-04 * (FPS-45,52)**2
            V17=-1,48482E-04 * (FXR-42,23)**2
            V18= 2,26358E-04 * (FSS-53,66)**2
            V19=-4,12502E-07 * (PD-975,0)**2
            V20=-8,86055E-01 * (UF-1,72)**2
            V21=-2,41773E-01 * ALOG(UP)
            V22=-9,24934E-01 * ALOG(V)
            V23=-1,01741E-01 * ALOG(PD)
            ALNMTF=V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
           $ V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20 +
           $ V21 + V22 + V23
            AMTBF=EXP(ALNMTF)
            RETURN
           ,END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1 ESTMTF2

VARIABLES SN		TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	224	ALNMTF	REAL	
24	ALSCOH	REAL	IVAR	25	AMHTOH	REAL	IVAR
14	AMSHOH	REAL	NVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	13	AMUNOH	REAL	NVAR
27	ANRTS	REAL	IVAR	26	ATRNOH	REAL	IVAR
20	BF	REAL	IVAR	7	CC	REAL	IVAR

```
VARIABLES      SN  TYPE            RELOCATION
   10  CD          REAL            IVAR            12  DEPREP    REAL              NVAR
   12  FAN         REAL            IVAR            11  FDI       REAL              IVAR
   13  FEM         REAL            IVAR             0  FNRTS     REAL              NVAR
   14  FPS         REAL            IVAR            16  FSS       REAL              IVAR
   15  FXR         REAL            IVAR             6  IBMCOM    REAL              NVAR
    4  IBMNAV      REAL            NVAR             5  IBMSEN    REAL              NVAR
    2  IBOM        INTEGER         IVAR             3  ICAR      INTEGER           IVAR
    1  ICOM        INTEGER         IVAR            10  ICRCOM    REAL              NVAR
    7  ICRNAV      REAL            NVAR             3  IFGCOM    REAL              NVAR
    1  IFGNAV      REAL            NVAR             2  IFGSEN    REAL              NVAR
    0  ISEN        INTEGEP         IVAR            17  PD        REAL              IVAR
   21  UF          REAL            IVAR             4  UP        REAL              IVAR
    5  V           REAL            IVAR           174  V0        REAL
  175  V1          REAL                           206  V10       REAL
  207  V11         REAL                           210  V12       REAL
  211  V13         REAL                           212  V14       REAL
  213  V15         REAL                           214  V16       REAL
  215  V17         REAL                           216  V18       REAL
  217  V19         REAL                           176  V2        REAL
  220  V20         REAL                           221  V21       REAL
  222  V22         REAL                           223  V23       REAL
  177  V3          REAL                           200  V4        REAL
  201  V5          REAL                           202  V6        REAL
  203  V7          REAL                           204  V8        REAL
  205  V9          REAL                             6  W         REAL              IVAR

EXTERNALS          TYPE   ARGS
    ALOG           REAL     1 LIBRARY             EXP            REAL      1 LIBRARY

COMMON BLOCKS   LENGTH
    IVAR           24
    NVAR           13

STATISTICS
  PROGRAM LENGTH                 225B     149
  CM LABELED COMMON LENGTH        45B      37
```

```
      C**********************************************************************
      C SUBROUTINE TO PREDICT MTBMA (BASED ON OPERATING HOURS)
      C USING THE PER'S DEVELOPED IN PHASE 2
            SUBROUTINE ESTMTA2
            COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CO,FDI,FAN,FEM,FPS,FXR
           *,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
            COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
           $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
            REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
      C     CALCULATE TERMS OF THE REGRESSION EQUATION
            V0 = 1,47077E+01
            V1 =-7,85726E-01 * IFGCOM
            V2 =-1,17109E+00 * IBMNAV
            V3 =-1,18391E+00 * IBMCOM
            V4 =-5,71454E-01 * ICRNAV
            V5 =-1,07055E+00 * ICRCOM
            V6 =-2,81826E-06 * UP
            V7 =-2,00878E-01 * CD
            V8 = 8,02771E-03 * FDI
            V9 = 1,82938E-02 * FEM
            V10= 5,55100E-04 * (V-1281,0)
            V11=-1,15558E-02 * (W-31,2)
            V12= 1,12875E-02 * (FSS-79,0)
            V13=-3,73066E-01 * (UF-1,73)
            V14=-1,02032E-07 * (V-3226,0)**2
            V15= 1,35063E-04 * (W-65,3)**2
            V16= 2,21412E-04 * (FPS-45,52)**2
            V17=-1,71495E-04 * (FXR-42,23)**2
            V18= 2,11740E-04 * (FSS-53,66)**2
            V19=-3,13309E-07 * (PD-975,0)**2
            V20=-7,72170E-01 * (UF-1,72)**2
            V21=-2,69229E-01 * ALOG(UP)
            V22=-8,00724E-01 * ALOG(V)
            V23=-1,06125E-01 * ALOG(PD)
            ALNMTA= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
           $ V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20 + V21 +
           $ V22 + V23
            AMTBMA=EXP(ALNMTA)
            RETURN
            END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1   ESTMTA2

VARIABLES	SN	TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	224	ALNMTA	REAL	
24	ALSCOH	REAL	IVAR	25	AMHTOH	REAL	IVAR
14	AMSHOH	REAL	NVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	13	AMUNOH	REAL	NVAR
27	ANRTS	REAL	IVAR	26	ATRNOH	REAL	IVAR
20	BF	REAL	IVAR	7	CC	REAL	IVAR

```
VARIABLES      SN  TYPE          RELOCATION
   10  CD          REAL              IVAR        12  DEPREP    REAL               NVAR
   12  FAN         REAL              IVAR        11  FDI       REAL               IVAR
   13  FEM         REAL              IVAR         0  FNRTS     REAL               NVAR
   14  FPS         REAL              IVAR        16  FSS       REAL               IVAR
   15  FXR         REAL              IVAR         6  IBMCOM    REAL               NVAR
    4  IBMNAV      REAL              NVAR         5  IBMSEN    REAL               NVAR
    2  IBOM        INTEGER           IVAR         3  ICAR      INTEGER            IVAR
    1  ICOM        INTEGER           IVAR        10  ICRCOM    REAL               NVAR
    7  ICRNAV      REAL              NVAR         3  IFGCOM    REAL               NVAR
    1  IFGNAV      REAL              NVAR         2  IFGSEN    REAL               NVAR
    0  ISEN        INTEGER           IVAR        17  PD        REAL               IVAR
   21  UF          REAL              IVAR         4  UP        REAL               IVAR
    5  V           REAL              IVAR       174  V0        REAL
  175  V1          REAL                         206  V10       REAL
  207  V11         REAL                         210  V12       REAL
  211  V13         REAL                         212  V14       REAL
  213  V15         REAL                         214  V16       REAL
  215  V17         REAL                         216  V18       REAL
  217  V19         REAL                         176  V2        REAL
  220  V20         REAL                         221  V21       REAL
  222  V22         REAL                         223  V23       REAL
  177  V3          REAL                         200  V4        REAL
  201  V5          REAL                         202  V6        REAL
  203  V7          REAL                         204  V8        REAL
  205  V9          REAL                           6  W         REAL               IVAR

EXTERNALS             TYPE   ARGS
       ALOG           REAL      1 LIBRARY            EXP       REAL       1 LIBRARY

COMMON BLOCKS   LENGTH
       IVAR         24
       NVAR         13

STATISTICS
  PROGRAM LENGTH                 225B    149
  CM LABELED COMMON LENGTH        45B     37
```

```
SUBROUTINE ESTLSC2     73/74    OPT=1                              FTN 4.6+433B        79/05/15. 12.28.26        PAGE     1

          C*************************************************************************
          C SUBROUTINE TO PREDICT LOGISTICS SUPPORT COST PER OPERATING HOURS
          C USING THE PER'S DEVELOPED IN PHASE 2
                SUBROUTINE ESTLSC2
                COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
               +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
                COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
               $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
                REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
          C     CALCULATE TERMS OF THE REGRESSION EQUATION
                V0 =-7.97950E+00
                V1 = 7.85143E-01 * IFGCOM
                V2 = 1.14876E+00 * IBMNAV
                V3 = 1.07719E+00 * IBMCOM
                V4 = 1.91500E-01 * CD
                V5 =-1.22007E-02 * FDI
                V6 =-1.72307E-02 * FEM
                V7 =-9.49029E-03 * FXR
                V8 =-8.36154E-03 * FSS
                V9 =-3.35635E-04 * (V-1333.0)
                V10= 1.98641E-02 * (W-32.3)
                V11= 6.72593E-08 * (V-3222.0)**2
                V12=-1.05350E-04 * (W-65.3)**2
                V13=-4.24991E-08 * (CC-2986.0)**2
                V14=-4.36525E-04 * (FPS-45.48)**2
                V15= 7.79904E-01 * (UF-1.72)**2
                V16= 5.64131E-01 * ALOG(UP)
                V17= 4.61602E-01 * ALOG(V)
                V18= 1.47264E-01 * ALOG(PD)
                ALNLSC= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
               $ V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18
                ALSCOH=EXP(ALNLSC)
                RETURN
                END


SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1 ESTLSC2

VARIABLES      SN   TYPE           RELOCATION
   11 ALFDOH        REAL             NVAR          164 ALNLSC     REAL
   24 ALSCOH        REAL             IVAR           25 AMHTOH     REAL              IVAR
   14 AMSHOH        REAL             NVAR           22 AMTBF      REAL              IVAR
   23 AMTBMA        REAL             IVAR           13 AMUNOH     REAL              NVAR
   27 ANRTS         REAL             IVAR           26 ATRNOH     REAL              IVAR
   20 BF            REAL             IVAR            7 CC         REAL              IVAR
   10 CD            REAL             IVAR           12 DEPREP     REAL              NVAR
   12 FAN           REAL             IVAR           11 FDI        REAL              IVAR
   13 FEM           REAL             IVAR            0 FNRTS      REAL              NVAR
   14 FPS           REAL             IVAR           16 FSS        REAL              IVAR
   15 FXR           REAL             IVAR            6 IBMCOM     REAL              NVAR
    4 IBMNAV        REAL             NVAR            5 IBMSEN     REAL              NVAR
```

```
VARIABLES      SN  TYPE            RELOCATION
    2  IBOM        INTEGER             IVAR           3  ICAR      INTEGER           IVAR
    1  ICOM        INTEGER             IVAR          10  ICRCOM    REAL              NVAR
    7  ICRNAV      REAL                NVAR           3  IFGCOM    REAL              NVAR
    1  IFGNAV      REAL                NVAR           2  IFGSEN    REAL              NVAR
    0  ISEN        INTEGER             IVAR          17  PD        REAL              IVAR
   21  UF          REAL                IVAR           4  UP        REAL              IVAR
    5  V           REAL                IVAR         141  V0        REAL
  142  V1          REAL                             153  V10       REAL
  154  V11         REAL                             155  V12       REAL
  156  V13         REAL                             157  V14       REAL
  160  V15         REAL                             161  V16       REAL
  162  V17         REAL                             163  V18       REAL
  143  V2          REAL                             144  V3        REAL
  145  V4          REAL                             146  V5        REAL
  147  V6          REAL                             150  V7        REAL
  151  V8          REAL                             152  V9        REAL
    6  W           REAL                IVAR

EXTERNALS          TYPE    ARGS
      ALOG         REAL     1 LIBRARY                    EXP       REAL       1 LIBRARY

COMMON BLOCKS   LENGTH
      IVAR          24
      NVAR          13

STATISTICS
  PROGRAM LENGTH                   165B    117
  CM LABELED COMMON LENGTH          45B     37
```

```
      C***************************************************************************
      C SUBROUTINE TO PREDICT THE FIELD LOGISTICS SUPPORT COST PER OPERATING
      C                                         HOUR
      C      USING PER'S DEVELOPED IN PHASE 2
             SUBROUTINE ESTLFD2
             COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
            +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
             COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
            $ ICRNAV,ICRCUM,ALFDOH,DEPREP,AMUNOH,AMSHOH
             REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
      C      CALCULATE TERMS OF THE REGRESSION EQUATION
             V0 =-8.63885E+00
             V1 = 8.34904E-01 * IFGCOM
             V2 = 8.53195E-01 * IBMNAV
             V3 = 9.13951E-01 * IBMCOM
             V4 = 1.32584E-02 * W
             V5 = 1.99949E-01 * CD
             V6 =-1.35760E-02 * FDI
             V7 =-2.43521E-02 * FEM
             V8 =-1.13244E-02 * FXR
             V9 =-1.16312E-02 * FSS
             V10=-2.74178E-04 * (V-1333.0)
             V11= 3.58369E-08 * (V-3222.0)**2
             V12=-3.84904E-08 * (CC-2986.0)**2
             V13=-3.06241E-04 * (FPS-45.48)**2
             V14= 6.56704E-01 * (UF-1.72)**2
             V15= 5.20085E-01 * ALOG(UP)
             V16= 5.47207E-01 * ALOG(V)
             V17= 1.16195E-01 * ALOG(PD)
             ALNFLD= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
            $ V11 + V12 + V13 + V14 + V15 + V16 + V17
             ALFDOH= EXP(ALNFLD)
             RETURN
             END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1 ESTLFD2

VARIABLES SN		TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	154	ALNFLD	REAL	
24	ALSCOH	REAL	IVAR	25	AMHTOH	REAL	IVAR
14	AMSHOH	REAL	NVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	13	AMUNOH	REAL	NVAR
27	ANRTS	REAL	IVAR	26	ATRNOH	REAL	IVAR
20	BF	REAL	IVAR	7	CC	REAL	IVAR
10	CD	REAL	IVAR	12	DEPREP	REAL	NVAR
12	FAN	REAL	IVAR	11	FDI	REAL	IVAR
13	FEM	REAL	IVAR	0	FNRTS	REAL	NVAR
14	FPS	REAL	IVAR	16	FSS	REAL	IVAR
15	FXR	REAL	IVAR	6	IBMCOM	REAL	NVAR
4	IBMNAV	REAL	NVAR	5	IBMSEN	REAL	NVAR

```
VARIABLES      SN  TYPE          RELOCATION
     2  IBOM       INTEGER             IVAR            3  ICAR       INTEGER            IVAR
     1  ICOM       INTEGER             IVAR           10  ICRCOM     REAL               NVAR
     7  ICRNAV     REAL                NVAR            3  IFGCOM     REAL               NVAR
     1  IFGNAV     REAL                NVAR            2  IFGSEN     REAL               NVAR
     0  ISEN       INTEGER             IVAR           17  PD         REAL               IVAR
    21  UF         REAL                IVAR            4  UP         REAL               IVAR
     5  V          REAL                IVAR          132  V0         REAL
   133  V1         REAL                              144  V10        REAL
   145  V11        REAL                              146  V12        REAL
   147  V13        REAL                              150  V14        REAL
   151  V15        REAL                              152  V16        REAL
   153  V17        REAL                              134  V2         REAL
   135  V3         REAL                              136  V4         REAL
   137  V5         REAL                              140  V6         REAL
   141  V7         REAL                              142  V8         REAL
   143  V9         REAL                                6  W          REAL               IVAR

EXTERNALS          TYPE     ARGS
     ALOG          REAL        1 LIBRARY                  EXP        REAL       1 LIBRARY

COMMON BLOCKS   LENGTH
     IVAR           24
     NVAR           13

STATISTICS
  PROGRAM LENGTH                 155B      109
  CM LABELED COMMON LENGTH        45B       37
```

```
C*****************************************************************************
C SUBROUTINE TO PREDICT THE STANDARD COST OF DEPOT REPAIR
C     USING PER'S DEVELOPED IN PHASE 2
      SUBROUTINE ESTDEP2
      COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
     +,FSS,PO,BF,UF,AMTBF,AMTBMA,ALSCOM,AMHTOH,ATRNOH,ANRTS
      COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
     $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
      REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
C     CALCULATE TERMS OF THE REGRESSION EQUATION
      V0 =-2.07078E-01
      V1 =-6.77565E-01 * IFGSEN
      V2 =-6.40011E-01 * IFGCOM
      V3 =-2.64318E-01 * IBMNAV
      V4 = 3.75071E-01 * IBMSEN
      V5 =-2.76094E-01 * ICRNAV
      V6 = 3.79270E-03 * FDI
      V7 =-1.61279E-11 * (UP-199034.4)**2
      V8 = 6.59084E-08 * (V-3279.0)**2
      V9 =-2.77377E-04 * (W-66.0)**2
      V10= 9.32045E-08 * (CC-2730.0)**2
      V11= 3.68361E-04 * (FEM-42.69)**2
      V12= 5.19716E-04 * (FPS-46.82)**2
      V13= 5.59446E-01 * ALOG(UP)
      V14= 1.04766E-01 * ALOG(CC)
      ALNDEP= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
     $ V11 + V12 + V13 + V14
      DEPREP= EXP(ALNDEP)
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTDEP2

VARIABLES SN		TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	136	ALNDEP	REAL	
24	ALSCOM	REAL	IVAR	25	AMHTOH	REAL	IVAR
14	AMSHOH	REAL	NVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	13	AMUNOH	REAL	NVAR
27	ANRTS	REAL	IVAR	26	ATRNOH	REAL	IVAR
20	BF	REAL	IVAR	7	CC	REAL	IVAR
10	CD	REAL	IVAR	12	DEPREP	REAL	NVAR
12	FAN	REAL	IVAR	11	FDI	REAL	IVAR
13	FEM	REAL	IVAR	0	FNRTS	REAL	NVAR
14	FPS	REAL	IVAR	16	FSS	REAL	IVAR
15	FXR	REAL	IVAR	6	IBMCOM	REAL	NVAR
4	IBMNAV	REAL	NVAR	5	IBMSEN	REAL	NVAR
2	IBOM	INTEGER	IVAR	3	ICAR	INTEGER	IVAR
1	ICOM	INTEGER	IVAR	10	ICRCOM	REAL	NVAR
7	ICRNAV	REAL	NVAR	3	IFGCOM	REAL	NVAR
1	IFGNAV	REAL	NVAR	2	IFGSEN	REAL	NVAR

```
VARIABLES       SN  TYPE              RELOCATION
     0  ISEN        INTEGER               IVAR          17  PD        REAL                IVAR
    21  UF          REAL                  IVAR           4  UP        REAL                IVAR
     5  V           REAL                  IVAR         117  V0        REAL
   120  V1          REAL                               131  V10       REAL
   132  V11         REAL                               133  V12       REAL
   134  V13         REAL                               135  V14       REAL
   121  V2          REAL                               122  V3        REAL
   123  V4          REAL                               124  V5        REAL
   125  V6          REAL                               126  V7        REAL
   127  V8          REAL                               130  V9        REAL
     6  W           REAL                  IVAR

EXTERNALS           TYPE     ARGS
        ALOG        REAL      1 LIBRARY                    EXP       REAL        1 LIBRARY

COMMON BLOCKS    LENGTH
        IVAR         24
        NVAR         13

STATISTICS
  PROGRAM LENGTH                   137B        95
  CM LABELED COMMON LENGTH          45B        37
```

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SUBROUTINE ESTMMH2      73/74    OPT=1                              FTN 4.6+433B         79/05/15. 12.28.25          PAGE     1

            C*************************************************************************
            C SUBROUTINE TO PREDICT TOTAL MAINTENANCE MANHOURS (O + I) PER
            C OPERATING HOURS
            C USING THE PER'S DEVELOPED IN PHASE 2
                  SUBROUTINE ESTMMH2
                  COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
                 +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOM,AMHTOH,ATRNOH,ANRTS
                  COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
                 $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
                  REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
            C     CALCULATE TERMS OF THE REGRESSION EQUATION
                  V0 =-1.01402E+01
                  V1 =-1.99281E-01 * IFGSEN
                  V2 = 5.94624E-01 * IFGCOM
                  V3 = 5.77750E-01 * IBMNAV
                  V4 = 7.13241E-01 * IBMCOM
                  V5 = 2.57158E-01 * CD
                  V6 =-4.49100E-03 * FXR
                  V7 =-1.63707E-02 * FSS
                  V8 =-1.31567E-02 * (FDI-24.9)
                  V9 =-2.48421E-02 * (FEM-10.2)
                  V10=-4.03887E-03 * (FPS-5.01)
                  V11= 5.86632E-12 * (UP-187496.5)**2
                  V12=-3.16774E-08 * (CC-2955.0)**2
                  V13= 1.49297E-04 * (FDI-44.4)**2
                  V14=-2.01240E-04 * (FEM-44.8)**2
                  V15=-1.62314E-04 * (FPS-46.31)**2
                  V16= 1.89762E-07 * (PD-973.0)**2
                  V17= 3.61428E-01 * (UF-1.75)**2
                  V18= 5.98173E-01 * ALOG(UP)
                  V19= 1.88370E-01 * ALOG(V)
                  V20= 3.78954E-01 * ALOG(W)
                  ALNMMH= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
                 $ V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20
                  AMHTOH= EXP(ALNMMH)
                  RETURN
                  END

     SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
    1  ESTMMH2

VARIABLES     SN  TYPE            RELOCATION
   11  ALFDOH     REAL                NVAR          205  ALNMMH     REAL
   24  ALSCOH     REAL                IVAR           25  AMHTOH     REAL             IVAR
   14  AMSHOH     REAL                NVAR           22  AMTBF      REAL             IVAR
   23  AMTBMA     REAL                IVAR           13  AMUNOH     REAL             NVAR
   27  ANRTS      REAL                IVAR           26  ATRNOH     REAL             IVAR
   20  BF         REAL                IVAR            7  CC         REAL             IVAR
   10  CD         REAL                IVAR           12  DEPREP     REAL             NVAR
   12  FAN        REAL                IVAR           11  FDI        REAL             IVAR
   13  FEM        REAL                IVAR            0  FNRTS      REAL             NVAR
```

```
VARIABLES      SN  TYPE          RELOCATION
    14  FPS        REAL               IVAR          16  FSS       REAL          IVAR
    15  FXR        REAL               IVAR           6  IBMCOM    REAL          NVAR
     4  IBMNAV     REAL               NVAR           5  IBMSEN    REAL          NVAR
     2  IBOM       INTEGER            IVAR           3  ICAR      INTEGER       IVAR
     1  ICOM       INTEGER            IVAR          10  ICRCOM    REAL          NVAR
     7  ICRNAV     REAL               NVAR           3  IFGCOM    REAL          NVAR
     1  IFGNAV     REAL               NVAR           2  IFGSEN    REAL          NVAR
     0  ISEN       INTEGER            IVAR          17  PD        REAL          IVAR
    21  UF         REAL               IVAR           4  UP        REAL          IVAR
     5  V          REAL               IVAR         160  V0        REAL
   161  V1         REAL                            172  V10       REAL
   173  V11        REAL                            174  V12       REAL
   175  V13        REAL                            176  V14       REAL
   177  V15        REAL                            200  V16       REAL
   201  V17        REAL                            202  V18       REAL
   203  V19        REAL                            162  V2        REAL
   204  V20        REAL                            163  V3        REAL
   164  V4         REAL                            165  V5        REAL
   166  V6         REAL                            167  V7        REAL
   170  V8         REAL                            171  V9        REAL
     6  W          REAL               IVAR

EXTERNALS           TYPE    ARGS
     ALOG           REAL      1 LIBRARY             EXP       REAL       1 LIBRARY

COMMON BLOCKS    LENGTH
     IVAR           24
     NVAR           13

STATISTICS
  PROGRAM LENGTH                 206B      134
  CM LABELED COMMON LENGTH        45B       37
```

```
C****************************************************************************
C SUBROUTINE TO PREDICT THE UNSCHEDULED MAINTENANCE MANHOURS PER
C                            OPERATING HOUR
C        USING PER'S DEVELOPED IN PHASE 2
      SUBROUTINE ESTMUN2
      COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
     *,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
      COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
     $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
      REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
C     CALCULATE TERMS OF THE REGRESSION EQUATION
      V0 =-9.99109E+00
      V1 =-2.49989E-01 * IFGSEN
      V2 = 3.40972E-01 * IFGCOM
      V3 = 8.70714E-01 * IBMNAV
      V4 = 4.94586E-01 * IBMCOM
      V5 =-7.50874E-03 * FDI
      V6 =-1.11264E-02 * FSS
      V7 = 1.88852E-04 * (CC-1177.0)
      V8 =-1.75962E-02 * (FEM-10.2)
      V9 =-5.33356E-04 * (PD-335.0)
      V10= 2.14493E-08 * (V-3245.0)**2
      V11=-4.52237E-08 * (CC-2955.0)**2
      V12= 5.73676E-02 * (CD-2.36)**2
      V13=-1.62015E-04 * (FEM-44.8)**2
      V14= 3.43738E-07 * (PD-973.0)**2
      V15= 5.19028E-01 * (UF-1.75)**2
      V16= 4.63360E-01 * ALOG(UP)
      V17= 3.07818E-01 * ALOG(W)
      V18= 2.52781E-01 * ALOG(PD)
      ALNMUN= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
     $ V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18
      AMUNOH= EXP(ALNMUN)
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1 ESTMUN2

VARIABLES		SN TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	170	ALNMUN	REAL	
24	ALSCOH	REAL	IVAR	25	AMHTOH	REAL	IVAR
14	AMSHOH	REAL	NVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	13	AMUNOH	REAL	NVAR
27	ANRTS	REAL	IVAR	26	ATRNOH	REAL	IVAR
20	BF	REAL	IVAR	7	CC	REAL	IVAR
10	CD	REAL	IVAR	12	DEPREP	REAL	NVAR
12	FAN	REAL	IVAR	11	FDI	REAL	IVAR
13	FEM	REAL	IVAR	0	FNRTS	REAL	NVAR
14	FPS	REAL	IVAR	16	FSS	REAL	IVAR
15	FXR	REAL	IVAR	6	IBMCOM	REAL	NVAR

```
VARIABLES      SN  TYPE           RELOCATION
     4  IBMNAV     REAL                  NVAR         5  IBMSEN    REAL              NVAR
     2  IBOM       INTEGER               IVAR         3  ICAR      INTEGER           IVAR
     1  ICOM       INTEGER               IVAR        10  ICRCOM    REAL              NVAR
     7  ICRNAV     REAL                  NVAR         3  IFGCOM    REAL              NVAR
     1  IFGNAV     REAL                  NVAR         2  IFGSEN    REAL              NVAR
     0  ISEN       INTEGER               IVAR        17  PC        REAL              IVAR
    21  UF         REAL                  IVAR         4  UP        REAL              IVAR
     5  V          REAL                  IVAR       145  V0        REAL
   146  V1         REAL                               157  V10       REAL
   160  V11        REAL                               161  V12       REAL
   162  V13        REAL                               163  V14       REAL
   164  V15        REAL                               165  V16       REAL
   166  V17        REAL                               167  V18       REAL
   147  V2         REAL                               150  V3        REAL
   151  V4         REAL                               152  V5        REAL
   153  V6         REAL                               154  V7        REAL
   155  V8         REAL                               156  V9        REAL
     6  W          REAL                  IVAR

EXTERNALS         TYPE    ARGS
       ALOG       REAL      1 LIBRARY                      EXP       REAL        1 LIBRARY

COMMON BLOCKS   LENGTH
       IVAR         24
       NVAR         13

STATISTICS
  PROGRAM LENGTH                171B      121
  CM LABELED COMMON LENGTH       45B       37
```

```
SUBROUTINE ESTMSH2     73/74    OPT=1                          FTN 4.6+433B       79/05/15. 12.28.26        PAGE     1

      C*************************************************************************
      C SUBROUTINE TO PREDICT THE SHOP MANHOURS PER OPERATING HOUR
      C     USING PER'S DEVELOPED IN PHASE 2
            SUBROUTINE ESTMSH2
            COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
           +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
            COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
           $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
            REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
      C     CALCULATE TERMS OF THE REGRESSION EQUATION
            V0 =-1.14609E+01
            V1 = 8.42691E-01 * IFGCOM
            V2 = 4.10211E-01 * IBMNAV
            V3 = 9.39630E-01 * IBMCOM
            V4 =-1.76397E-02 * FDI
            V5 =-5.47801E-03 * FPS
            V6 =-1.90886E-02 * FSS
            V7 = 3.15922E-01 * (CD-1.22)
            V8 =-3.23793E-02 * (FEM-10.2)
            V9 = 7.34387E-12 * (UP-187496.5)**2
            V10=-5.60418E-02 * (CD-2.36)**2
            V11=-3.76169E-04 * (FEM-44.8)**2
            V12= 2.43015E-01 * (UF-1.75)**2
            V13= 6.70829E-01 * ALOG(UP)
            V14= 5.65786E-01 * ALOG(V)
            ALNSHP= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
           $ V11 + V12 + V13 + V14
            AMSHOH= EXP(ALNSHP)
            RETURN
            END

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1   ESTMSH2

VARIABLES    SN   TYPE          RELOCATION
  11  ALFDOH      REAL              NVAR        135  ALNSHP    REAL
  24  ALSCOH      REAL              IVAR         25  AMHTOH    REAL          IVAR
  14  AMSHOH      REAL              NVAR         22  AMTBF     REAL          IVAR
  23  AMTBMA      REAL              IVAR         13  AMUNOH    REAL          NVAR
  27  ANRTS       REAL              IVAR         26  ATRNOH    REAL          IVAR
  20  BF          REAL              IVAR          7  CC        REAL          IVAR
  10  CD          REAL              IVAR         12  DEPREP    REAL          NVAR
  12  FAN         REAL              IVAR         11  FDI       REAL          IVAR
  13  FEM         REAL              IVAR          0  FNRTS     REAL          NVAR
  14  FPS         REAL              IVAR         16  FSS       REAL          IVAR
  15  FXR         REAL              IVAR          6  IBMCOM    REAL          NVAR
   4  IBMNAV      REAL              NVAR          5  IBMSEN    REAL          NVAR
   2  IBOM        INTEGER           IVAR          3  ICAR      INTEGER       IVAR
   1  ICOM        INTEGER           IVAR         10  ICRCOM    REAL          NVAR
   7  ICRNAV      REAL              NVAR          3  IFGCOM    REAL          NVAR
   1  IFGNAV      REAL              NVAR          2  IFGSEN    REAL          NVAR
```

```
VARIABLES       SN   TYPE              RELOCATION
      0  ISEN        INTEGER                IVAR            17   PD          REAL               IVAR
     21  UF          REAL                   IVAR             4   UP          REAL               IVAR
      5  V           REAL                   IVAR           118   V0          REAL
    117  V1          REAL                                  130   V10         REAL
    131  V11         REAL                                  132   V12         REAL
    133  V13         REAL                                  134   V14         REAL
    120  V2          REAL                                  121   V3          REAL
    122  V4          REAL                                  123   V5          REAL
    124  V6          REAL                                  125   V7          REAL
    126  V8          REAL                                  127   V9          REAL
      6  W           REAL                   IVAR

EXTERNALS              TYPE     ARGS
         ALOG          REAL        1 LIBRARY                    EXP          REAL          1 LIBRARY

COMMON BLOCKS    LENGTH
         IVAR         24
         NVAR         13

STATISTICS
  PROGRAM LENGTH                  136B      94
  CM LABELED COMMON LENGTH         45B      37
```

```
      C*******************************************************************
      C SUBROUTINE TO PREDICT TRAINING COSTS PER OPERATING HOUR
      C USING THE PER'S DEVELOPED IN PHASE 2
            SUBROUTINE ESTTRN2
            COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
           +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOM,AMHTOH,ATRNOH,ANRTS
            COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
           $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
            REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
      C     CALCULATE TERMS OF THE REGRESSION EQUATION
            V0 =-7.69223E+00
            V1 = 7.13243E-01 * IFGCOM
            V2 =-9.69315E-01 * IBMSEN
            V3 =-1.10568E+00 * ICRNAV
            V4 =-6.32479E-01 * ICRCOM
            V5 =-5.16036E-06 * UP
            V6 = 9.87981E-03 * W
            V7 =-1.41283E-02 * FDI
            V8 =-3.70668E-01 * UF
            V9 =-4.82311E-04 * (V-1345.0)
            V10= 4.62817E-04 * (CC-1191.0)
            V11= 3.18476E-01 * (CD-1.25)
            V12=-2.17302E-02 * (FEM-8.57)
            V13=-6.89779E-03 * (FPS-5.20)
            V14=-1.47657E-02 * (FSS-79.4)
            V15= 7.04357E-08 * (V-3220.0)**2
            V16=-1.16361E-07 * (CC-2991.0)**2
            V17=-1.50232E-01 * (CD-2.37)**2
            V18=-4.24823E-04 * (FEM-43.07)**2
            V19=-6.70382E-04 * (FPS-45.7)**2
            V20=-2.08351E-04 * (FSS-54.2)**2
            V21= 6.22657E-01 * ALOG(UP)
            V22= 1.11348E+00 * ALOG(V)
            V23=-7.61468E-01 * ALOG(CC)
            V24= 2.57936E-01 * ALOG(PD)
            ALNTRN= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
           $ V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20 +
           $ V21 + V22 + V23 + V24
            ATRNOH=EXP(ALNTRN)
            RETURN
            END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTTRN2

VARIABLES SN		TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	237	ALNTRN	REAL	
24	ALSCOM	REAL	IVAR	25	AMHTOH	REAL	IVAR
14	AMSHOH	REAL	NVAR	22	AMTBF	REAL	IVAR
23	AMTBMA	REAL	IVAR	13	AMUNOH	REAL	NVAR
27	ANRTS	REAL	IVAR	26	ATRNOH	REAL	IVAR

```
      SUBROUTINE ESTTRN2     73/74    OPT=1                               FTN 4.6+433B        79/05/15. 12.28.26        PAGE     2

VARIABLES      SN  TYPE           RELOCATION
    20  BF         REAL                 IVAR                 7  CC        REAL            IVAR
    10  CD         REAL                 IVAR                12  DEPREP    REAL            NVAR
    12  FAN        REAL                 IVAR                11  FDI       REAL            IVAR
    13  FEM        REAL                 IVAR                 0  FNRTS     REAL            NVAR
    14  FPS        REAL                 IVAR                16  FSS       REAL            IVAR
    15  FXR        REAL                 IVAR                 6  IBMCOM    REAL            NVAR
     4  IBMNAV     REAL                 NVAR                 5  IBMSEN    REAL            NVAR
     2  IBOM       INTEGER              IVAR                 3  ICAR      INTEGER         IVAR
     1  ICOM       INTEGER              IVAR                10  ICRCOM    REAL            NVAR
     7  ICRNAV     REAL                 NVAR                 3  IFGCOM    REAL            NVAR
     1  IFGNAV     REAL                 NVAR                 2  IFGSEN    REAL            NVAR
     0  ISEN       INTEGER              IVAR                17  PD        REAL            IVAR
    21  UF         REAL                 IVAR                 4  UP        REAL            IVAR
     5  V          REAL                 IVAR               206  V0        REAL
   207  V1         REAL                                    220  V10       REAL
   221  V11        REAL                                    222  V12       REAL
   223  V13        REAL                                    224  V14       REAL
   225  V15        REAL                                    226  V16       REAL
   227  V17        REAL                                    230  V18       REAL
   231  V19        REAL                                    210  V2        REAL
   232  V20        REAL                                    233  V21       REAL
   234  V22        REAL                                    235  V23       REAL
   236  V24        REAL                                    211  V3        REAL
   212  V4         REAL                                    213  V5        REAL
   214  V6         REAL                                    215  V7        REAL
   216  V8         REAL                                    217  V9        REAL
     6  W          REAL                 IVAR

EXTERNALS        TYPE    ARGS
      ALOG       REAL      1 LIBRARY                        EXP       REAL         1 LIBRARY

COMMON BLOCKS   LENGTH
      IVAR          24
      NVAR          13

STATISTICS
  PROGRAM LENGTH                 240B       160
  CM LABELED COMMON LENGTH        45B        37
```

```
C***********************************************************************
C SUBROUTINE TO PREDICT NRTS PERCENTAGE
C USING THE PER'S DEVELOPED IN PHASE 2
      SUBROUTINE ESTNRT2
      COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
     $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
      COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
     *,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
      REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
C     CALCULATE TERMS OF THE REGRESSION EQUATION
      V0 =-4.25353E+01
      V1 = 3.99251E-03 * V
      V2 = 1.27681E-01 * FDI
      V3 =-3.07291E+00 * UF
      V4 =-2.48616E-05 * (UP-39834.87)
      V5 =-5.75510E-01 * (W-33.1)
      V6 = 3.93942E-01 * (FEM-9.69)
      V7 = 2.43035E-01 * (FXR-8.50)
      V8 = 2.65801E-03 * (W-66.9)**2
      V9 = 6.61377E-07 * (CC-3018.0)**2
      V10= 1.22326E-02 * (FEM-44.09)**2
      V11= 4.19569E-03 * (FXR-42.50)**2
      V12=-5.78248E+00 * ALOG(V)
      V13= 1.76076E+01 * ALOG(W)
      ANRTS= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
     $ V11 + V12 + V13
      RETURN
      END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
  1 ESTNRT2

VARIABLES

SN		TYPE	RELOCATION	SN		TYPE	RELOCATION
11	ALFDOH	REAL	NVAR	24	ALSCOH	REAL	IVAR
25	AMHTOH	REAL	IVAR	14	AMSHOH	REAL	NVAR
22	AMTBF	REAL	IVAR	23	AMTBMA	REAL	IVAR
13	AMUNOH	REAL	NVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR
7	CC	REAL	IVAR	10	CD	REAL	IVAR
12	DEPREP	REAL	NVAR	12	FAN	REAL	IVAR
11	FDI	REAL	IVAR	13	FEM	REAL	IVAR
0	FNRTS	REAL	NVAR	14	FPS	REAL	IVAR
16	FSS	REAL	IVAR	15	FXR	REAL	IVAR
6	IBMCOM	REAL	NVAR	4	IBMNAV	REAL	NVAR
5	IBMSEN	REAL	NVAR	2	IBOM	INTEGER	IVAR
3	ICAR	INTEGER	IVAR	1	ICOM	INTEGER	IVAR
10	ICRCOM	REAL	NVAR	7	ICRNAV	REAL	NVAR
3	IFGCOM	REAL	NVAR	1	IFGNAV	REAL	NVAR
2	IFGSEN	REAL	NVAR	0	ISEN	INTEGER	IVAR
17	PD	REAL	IVAR	21	UF	REAL	IVAR
4	UP	REAL	IVAR	5	V	REAL	IVAR

```
VARIABLES      SN  TYPE           RELOCATION
   115  V0         REAL                                116  V1        REAL
   127  V10        REAL                                130  V11       REAL
   131  V12        REAL                                132  V13       REAL
   117  V2         REAL                                120  V3        REAL
   121  V4         REAL                                122  V5        REAL
   123  V6         REAL                                124  V7        REAL
   125  V8         REAL                                126  V9        REAL
     6  W          REAL                IVAR

EXTERNALS        TYPE     ARGS
     ALOG        REAL        1 LIBRARY

COMMON BLOCKS   LENGTH
     NVAR          13
     IVAR          24

STATISTICS
  PROGRAM LENGTH                 133B      91
  CM LABELED COMMON LENGTH        45B      37
```

```
      C*****************************************************************************
      C      SUBROUTINE TO PREDICT THE FIELD LOGISTICS SUPPORT COST
      C      PER OPERATING HOURS
      C      USING PER'S DEVELOPED IN PHASE 2
      C     ****   ****    W I T H    N R T S     ****    ****
             SUBROUTINE ESTLFDN
             COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
            +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
             COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
            $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
             COMMON/WNRT/ENRTS
             COMMON/VNRT/LFDNRT,TMHNRT,SHPNRT
             REAL LFDNRT,LFDN
             REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
      C      CALCULATE TERMS OF THE REGRESSION EQUATION
             V0 =-5.92124E+00
             V1 = 6.90411E-01 * IFGCOM
             V2 = 8.44373E-01 * IBMNAV
             V3 = 7.34623E-01 * IBMCOM
             V4 = 2.21346E-01 * CD
             V5 =-1.15577E-02 * FDI
             V6 =-1.96502E-02 * FEM
             V7 =-7.38385E-03 * FXR
             V8 =-1.08125E-02 * FSS
             V9 =-2.27836E-08 * (CC-2986.0)**2
             V10=-3.10974E-04 * (FPS-45.48)**2
             V11= 2.15236E-07 * (PD-979.0)**2
             V12= 6.47959E-01 * (UF-1.72)**2
             V13=-8.22418E-03 * ENRTS
             V14= 4.77659E-01 * ALOG(UP)
             V15= 5.22663E-01 * ALOG(W)
             V16= 1.40378E-01 * ALOG(PD)
             LFDN= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
            $ V11 + V12 + V13 + V14 + V15 + V16
             LFDNRT= EXP(LFDN)
             RETURN
             END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTLFDN

SN	VARIABLES	TYPE	RELOCATION	SN	VARIABLES	TYPE	RELOCATION
11	ALFDOH	REAL	NVAR	24	ALSCOH	REAL	IVAR
25	AMHTOH	REAL	IVAR	14	AMSHOH	REAL	NVAR
22	AMTBF	REAL	IVAR	23	AMTBMA	REAL	IVAR
13	AMUNOH	REAL	NVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR
7	CC	REAL	IVAR	10	CD	REAL	IVAR
12	DEPREP	REAL	NVAR	0	ENRTS	REAL	WNRT
12	FAN	REAL	IVAR	11	FDI	REAL	IVAR
13	FEM	REAL	IVAR	0	FNRTS	REAL	NVAR

```
VARIABLES       SN  TYPE              RELOCATION
    14  FPS         REAL                  IVAR            16  FSS         REAL                IVAR
    15  FXR         REAL                  IVAR             6  IBMCOM      REAL                NVAR
     4  IBMNAV      REAL                  NVAR             5  IBMSEN      REAL                NVAR
     2  IBOM        INTEGER               IVAR             3  ICAR        INTEGER             IVAR
     1  ICOM        INTEGER               IVAR            10  ICRCOM      REAL                NVAR
     7  ICRNAV      REAL                  NVAR             3  IFGCOM      REAL                NVAR
     1  IFGNAV      REAL                  NVAR             2  IFGSEN      REAL                NVAR
     0  ISEN        INTEGER               IVAR           126  LFON        REAL
     0  LFONRT      REAL                  VNRT            17  PD          REAL                IVAR
     2  SHPNRT      REAL                  VNRT             1  TMHNRT      REAL                VNRT
    21  UF          REAL                  IVAR             4  UP          REAL                IVAR
     5  V           REAL                  IVAR           127  V0          REAL
   130  V1          REAL                                 141  V10         REAL
   142  V11         REAL                                 143  V12         REAL
   144  V13         REAL                                 145  V14         REAL
   146  V15         REAL                                 147  V16         REAL
   131  V2          REAL                                 132  V3          REAL
   133  V4          REAL                                 134  V5          REAL
   135  V6          REAL                                 136  V7          REAL
   137  V8          REAL                                 140  V9          REAL
     6  W           REAL                  IVAR

EXTERNALS           TYPE    ARGS
        ALOG        REAL      1 LIBRARY                      EXP         REAL        1 LIBRARY

COMMON BLOCKS    LENGTH
        IVAR         24
        NVAR         13
        WNRT          1
        VNRT          3

STATISTICS
  PROGRAM LENGTH                        150B        104
  CM LABELED COMMON LENGTH               51B         41
```

```
C*********************************************************************
C      SUBROUTINE TO PREDICT TOTAL MAINTENANCE MANHOURS (O+I)
C      PER OPERATING HOURS
C      USING PER'S DEVELOPED IN PHASE 2
C      ****    ****    W I T H    N R T S     ****    ****
       SUBROUTINE ESTMMHN
       COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
      +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOH,AMHTOH,ATRNOH,ANRTS
       COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
      $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
       COMMON/WNRT/ENRTS
       COMMON/VNRT/LFDNRT,TMHNRT,SMPNRT
       REAL LFDNRT
       REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
C      CALCULATE TERMS OF THE REGRESSION EQUATION
       V0 =-9.41368E+00
       V1 =-2.03323E-01 * IFGSEN
       V2 = 5.45295E-01 * IFGCOM
       V3 = 6.19003E-01 * IBMNAV
       V4 = 6.71232E-01 * IBMCOM
       V5 = 2.18919E-01 * CD
       V6 =-1.62102E-02 * FSS
       V7 = 7.83621E-05 * (CC-1177.0)
       V8 =-1.22770E-02 * (FDI-24.9)
       V9 =-2.21381E-02 * (FEM-10.2)
       V10 = 6.53446E-12 * (UP-187496.5)**2
       V11=-3.58908E-08 * (CC-2955.0)**2
       V12= 1.08496E-04 * (FDI-44.4)**2
       V13=-1.68595E-04 * (FEM-44.8)**2
       V14=-2.12327E-04 * (FPS-46.31)**2
       V15= 1.76274E-07 * (PD-973.0)**2
       V16= 3.31674E-01 * (UF-1.75)**2
       V17=-3.98840E-03 * ENRTS
       V18= 5.69582E-01 * ALOG(UP)
       V19= 1.79180E-01 * ALOG(V)
       V20= 3.13607E-01 * ALOG(W)
       TMHN= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
      $ V11 + V12 + V13 + V14 + V15 + V16 + V17 + V18 + V19 + V20
       TMHNRT= EXP(TMHN)
       RETURN
       END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTMMHN

VARIABLES SN		TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	24	ALSCOH	REAL	IVAR
25	AMHTOH	REAL	IVAR	14	AMSHOH	REAL	NVAR
22	AMTBF	REAL	IVAR	23	AMTBMA	REAL	IVAR
13	AMUNOH	REAL	NVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR

```
VARIABLES        SN  TYPE              RELOCATION
      7  CC          REAL                 IVAR         10  CD          REAL              IVAR
     12  DEPREP      REAL                 NVAR          0  ENRTS       REAL              WNRT
     12  FAN         REAL                 IVAR         11  FDI         REAL              IVAR
     13  FEM         REAL                 IVAR          0  FNRTS       REAL              NVAR
     14  FPS         REAL                 IVAR         16  FSS         REAL              IVAR
     15  FXR         REAL                 IVAR          6  IBMCOM      REAL              NVAR
      4  IBMNAV      REAL                 NVAR          5  IBMSEN      REAL              NVAR
      2  IBOM        INTEGER              IVAR          3  ICAR        INTEGER           IVAR
      1  ICOM        INTEGER              IVAR         10  ICRCOM      REAL              NVAR
      7  ICRNAV      REAL                 NVAR          3  IFGCOM      REAL              NVAR
      1  IFGNAV      REAL                 NVAR          2  IFGSEN      REAL              NVAR
      0  ISEN        INTEGER              IVAR          0  LFDNRT      REAL              VNRT
     17  PD          REAL                 IVAR          2  SHPNRT      REAL              VNRT
    204  TMHN        REAL                               1  TMHNRT      REAL              VNRT
     21  UF          REAL                 IVAR          4  UP          REAL              IVAR
      5  V           REAL                 IVAR        157  V0          REAL
    160  V1          REAL                             171  V10         REAL
    172  V11         REAL                             173  V12         REAL
    174  V13         REAL                             175  V14         REAL
    176  V15         REAL                             177  V16         REAL
    200  V17         REAL                             201  V18         REAL
    202  V19         REAL                             161  V2          REAL
    203  V20         REAL                             162  V3          REAL
    163  V4          REAL                             164  V5          REAL
    165  V6          REAL                             166  V7          REAL
    167  V8          REAL                             170  V9          REAL
      6  W           REAL                 IVAR

EXTERNALS          TYPE    ARGS
       ALOG        REAL      1 LIBRARY                    EXP         REAL          1 LIBRARY

COMMON BLOCKS    LENGTH
       IVAR          24
       NVAR          13
       WNRT           1
       VNRT           3

STATISTICS
   PROGRAM LENGTH                   205B      133
   CM LABELED COMMON LENGTH          51B       41
```

```
C*************************************************************************
C         SUBROUTINE TO PREDICT THE SHOP MANHOURS
C         PER OPERATING HOURS
C         USING THE PER'S DEVELOPED IN PHASE 2
C         ****     ****     W I T H     N R T S     ****     ****
          SUBROUTINE ESTMSHN
          COMMON /IVAR/ ISEN,ICOM,IBOM,ICAR,UP,V,W,CC,CD,FDI,FAN,FEM,FPS,FXR
         +,FSS,PD,BF,UF,AMTBF,AMTBMA,ALSCOM,AMHTOH,ATRNOH,ANRTS
          COMMON/NVAR/FNRTS,IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,
         $ ICRNAV,ICRCOM,ALFDOH,DEPREP,AMUNOH,AMSHOH
          COMMON/WNRT/ENRTS
          COMMON/VNRT/LFDNRT,TMHNRT,SHPNRT
          REAL LFDNRT
          REAL IFGNAV,IFGSEN,IFGCOM,IBMNAV,IBMSEN,IBMCOM,ICRNAV,ICRCOM
C         CALCULATE TERMS OF THE REGRESSION EQUATION
          V0 =-1.12033E+01
          V1 = 7.69773E-01 * IFGCOM
          V2 = 3.89169E-01 * IBMNAV
          V3 = 8.43215E-01 * IBMCOM
          V4 =-1.67864E-02 * FDI
          V5 =-5.89773E-03 * FPS
          V6 =-1.86613E-02 * FSS
          V7 = 3.13626E-01 * (CD-1.22)
          V8 =-3.03262E-02 * (FEM-10.2)
          V9 = 6.92174E-12 * (UP-187496.5)**2
          V10=-5.70397E-02 * (CD-2.36)**2
          V11=-2.93880E-04 * (FEM-44.8)**2
          V12=-6.56723E-03 * ENRTS
          V13= 6.52610E-01 * ALOG(UP)
          V14= 5.55260E-01 * ALOG(V)
          SHOPN= V0 + V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8 + V9 + V10 +
         $ V11 + V12 + V13 + V14
          SHPNRT= EXP(SHOPN)
          RETURN
          END
```

SYMBOLIC REFERENCE MAP (R=1)

ENTRY POINTS
1 ESTMSHN

VARIABLES SN		TYPE	RELOCATION				
11	ALFDOH	REAL	NVAR	24	ALSCOM	REAL	IVAR
25	AMHTOH	REAL	IVAR	14	AMSHOH	REAL	NVAR
22	AMTBF	REAL	IVAR	23	AMTBMA	REAL	IVAR
13	AMUNOH	REAL	NVAR	27	ANRTS	REAL	IVAR
26	ATRNOH	REAL	IVAR	20	BF	REAL	IVAR
7	CC	REAL	IVAR	10	CD	REAL	IVAR
12	DEPREP	REAL	NVAR	0	ENRTS	REAL	WNRT
12	FAN	REAL	IVAR	11	FDI	REAL	IVAR
13	FEM	REAL	IVAR	0	FNRTS	REAL	NVAR
14	FPS	REAL	IVAR	16	FSS	REAL	IVAR
15	FXR	REAL	IVAR	6	IBMCOM	REAL	NVAR

```
VARIABLES     SN  TYPE              RELOCATION
     4  IBMNAV    REAL                NVAR           5  IBMSEN    REAL              NVAR
     2  IBOM      INTEGER             IVAR           3  ICAR      INTEGER           IVAR
     1  ICOM      INTEGER             IVAR          10  ICRCOM    REAL              NVAR
     7  ICRNAV    REAL                NVAR           3  IFGCOM    REAL              NVAR
     1  IFGNAV    REAL                NVAR           2  IFGSEN    REAL              NVAR
     0  ISEN      INTEGER             IVAR           0  LFDNRT    REAL              VNRT
    17  PD        REAL                IVAR         133  SHOPN     REAL
     2  SHPNRT    REAL                VNRT           1  TMHNRT    REAL              VNRT
    21  UF        REAL                IVAR           4  UP        REAL              IVAR
     5  V         REAL                IVAR         114  V0        REAL
   115  V1        REAL                             126  V10       REAL
   127  V11       REAL                             130  V12       REAL
   131  V13       REAL                             132  V14       REAL
   116  V2        REAL                             117  V3        REAL
   120  V4        REAL                             121  V5        REAL
   122  V6        REAL                             123  V7        REAL
   124  V8        REAL                             125  V9        REAL
     6  W         REAL                IVAR

EXTERNALS        TYPE     ARGS
       ALOG      REAL     1 LIBRARY                     EXP       REAL      1 LIBRARY

COMMON BLOCKS   LENGTH
       IVAR        24
       NVAR        13
       WNRT         1
       VNRT         3

STATISTICS
  PROGRAM LENGTH                134B       92
  CM LABELED COMMON LENGTH       51B       41
```

AVIONICS LABORATORY PREDICTIVE

OPERATIONS AND SUPPORT MODEL

(ALPOS)

....VERSION 2....

PREDICTIVE AVIONICS O & M COST MODEL
VERSION 2
DEVELOPED BY WESTINGHOUSE FOR THE AIR FORCE AVIONICS LABORATORY
UNDER CONTRACT F33615-77-C-1105
PAGE: 1

SYSTEM INPUT VARIABLES

QUANTITY OF SYSTEMS	533
COMMAND	TAC
AVIONICS AREA	NAVIGATION
AIRCRAFT TYPE	FIGHTER
OP/HR PER A/C PER MONTH	21.0
NO OF SYS PER SQN/WING	75.
NUMBER OF ALTERNATIVES	2
ALTERNATIVE ONE LRUS	2
ALTERNATIVE TWO LRUS	1

...NOTE: ESTIMATING RELATIONSHIPS DEVELOPED IN PHASE 2 ARE BEING EXECUTED...

...CALCULATED VALUE OF NRTS FOR EACH LRU IS BEING USED...

PREDICTIVE AVIONICS O & M COST MODEL
VERSION 2
DEVELOPED BY WESTINGHOUSE FOR THE AIR FORCE AVIONICS LABORATORY
UNDER CONTRACT F33615-77-C-1105
PAGE: 2

LRU INPUT VARIABLES

TEST-1 FOR PHASE 2 RELATIONSHIPS - LRUS FROM F-4E

IDENT. NUMBER	UNIT PRICE	VOLUME	WEIGHT	COMPTS. COUNT	PCT DIG.	PCT ANAL.	PCT E/M	PCT PS	PCT XMTR	PCT SS	POWER DIS.	BIT /FIT	UTIL. FACTOR	QPA
1)71B20	13721.	443.	17.7	410.	0.	86.	14.	0.	0.	86.	200.	0.	2.30	1.
2)71H00	30913.	1676.	30.6	78.	0.	24.	76.	0.	0.	24.	820.	0.	2.30	1.

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MODEL OUTPUTS

	COMP DENSITY	NO OF ** SPARES **	TOT LSC PER OH	FLD LSC PER OH	DEPOT REP COST	TRN PER OH	MTBF	MTBMA	TOT MMHOH	UNS MMHOH	SHOP MMHOH	NRTS
1)	.93	36.0 **	.652	.448	1126.	.190	509.	309.	.0420	.0143	.0256	.0626
2)	.85	52.0 **	.780	.454	2285.	.574	533.	357.	.0456	.0139	.0276	.2922
SUBSYSTEM TOTALS =			1.432	.903	3411.	.763	260.	166.	.0876	.0282	.0535	

	ANNUAL LSC	ANNUAL TNG COST	ANNUAL SE COST	TOTAL ANN. COST	SPARES COST	SE COST
1)	201286.	58573.	263279.	523137.	493956.	2632785.
2)	241048.	177194.	708287.	1126529.	1919476.	7082866.

TOTAL ANNUAL COST FOR ALTERNATIVE 1 = 1649666.
TOTAL NON-RECURRING COST FOR ALTERNATIVE 1 = 12129084.

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LRU INPUT VARIABLES

TEST-1 FOR PHASE 2 RELATIONSHIPS - LRUS FROM F-4E

IDENT. NUMBER	UNIT PRICE	VOLUME	WEIGHT	COMPTS. COUNT	PCT DIG.	PCT ANAL.	PCT E/M	PCT PS	PCT XMTR	PCT SS	POWER DIS.	BIT /FIT	UTIL. FACTOR	QPA
1)71L00	6681.	1444.	40.0	491.	0.	75.	0.	0.	25.	27.	212.	0.	2.30	1.

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MODEL OUTPUTS

	COMP DENSITY	NO OF ** SPARES **	TOT LSC PER OH	FLD LSC PER OH	DEPOT REP COST	TRN PER OH	MTBF	MTBMA	TOT MMHOH	UNS MMHOH	SHOP MMHOH	NRTS
1)	.34	66.0 **	1.098	.977	1194.	.344	185.	137.	.1099	.0289	.0767	.0730
SUBSYSTEM TOTALS =			1.098	.977	1194.	.344	185.	137.	.1099	.0289	.0767	

	ANNUAL LSC	ANNUAL TNG COST	ANNUAL SE COST	TOTAL ANN. COST	SPARES COST	SE COST
1)	339289.	106128.	128195.	573612.	440946.	1281950.

TOTAL ANNUAL COST FOR ALTERNATIVE 2 = 573612.
TOTAL NON-RECURRING COST FOR ALTERNATIVE 2 = 1722896.

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SYSTEM INPUT VARIABLES

QUANTITY OF SYSTEMS	533
COMMAND	TAC
AVIONICS AREA	NAVIGATION
AIRCRAFT TYPE	FIGHTER
OP/HR PER A/C PER MONTH	21.0
NO OF SYS PER SQN/WING	75.
NUMBER OF ALTERNATIVES	1
ALTERNATIVE ONE LRUS	3

...NOTE: ESTIMATING RELATIONSHIPS DEVELOPED IN PHASE 2 ARE BEING EXECUTED...

...INPUT VALUE OF NRTS FOR EACH LRU IS BEING USED.

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LRU INPUT VARIABLES

TEST-2 FOR PHASE 2 RELATIONSHIPS - LRUS FROM F-4E

IDENT, NUMBER	UNIT PRICE	VOLUME	WEIGHT	COMPTS, COUNT	PCT DIG,	PCT ANAL,	PCT E/M	PCT PS	PCT XMTR	PCT SS	POWER DIS,	BIT /FIT	UTIL, FACTOR	OPA	PCT NRTS
1)71B20	13721,	443,	17,7	410,	0,	86,	14,	0,	0,	86,	200,	0,	2,30	1,	13,
2)71H60	36913,	1676,	30,6	78,	0,	24,	76,	0,	0,	24,	820,	0,	2,30	1,	16,
3)71L80	6681,	1444,	40,0	491,	0,	75,	0,	0,	25,	27,	212,	0,	2,30	1,	27,

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MODEL OUTPUTS

	COMP DENSITY	NO OF ** SPARES **	TOT LSC PER OH	FLD LSC PER OH	DEPOT REP COST	TRN PER OH	MTBF	MTBMA	TOT MMHOH	UNS MMHOH	SHOP MMHOH	NRTS
1)	.93	42.0 **	.652	.448	1126.	.190	509.	309.	.0420	.0143	.0258	.1300
2)	.05	43.0 **	.780	.454	2285.	.574	533.	357.	.0456	.0139	.0276	.1600
3)	.34	109.0 **	1.098	.977	1194.	.344	185.	137.	.1099	.0289	.0767	.2700
SUBSYSTEM TOTALS =			2.530	1.880	4604.	1.107	108.	75.	.1975	.0571	.1301	

	ANNUAL LSC	ANNUAL TNG COST	ANNUAL SE COST	TOTAL ANN. COST	SPARES COST	SE COST
1)	201286.	58573.	263279.	523137.	576282.	2632785.
2)	241048.	177194.	708287.	1126529.	1587259.	7082866.
3)	339289.	106128.	128195.	573612.	728229.	1281950.

TOTAL ANNUAL COST FOR ALTERNATIVE 1 = 2223279.
TOTAL NON-RECURRING COST FOR ALTERNATIVE 1 = 13889372.

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SYSTEM INPUT VARIABLES

QUANTITY OF SYSTEMS	533
COMMAND	TAC
AVIONICS AREA	NAVIGATION
AIRCRAFT TYPE	FIGHTER
OP/HR PER A/C PER MONTH	21.0
NO OF SYS PER SQN/WING	75.
NUMBER OF ALTERNATIVES	1
ALTERNATIVE ONE LRUS	3

...NOTE: ESTIMATING RELATIONSHIPS DEVELOPED IN PHASE 2 ARE BEING EXECUTED...

...INPUT VALUE OF NRTS FOR EACH LRU IS BEING USED.

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LRU INPUT VARIABLES

TEST-3 FOR PHASE 2 REL.- NRTS USED IN LSC-FIELD,MMH-TOT,SHOP

IDENT, NUMBER	UNIT PRICE	VOLUME	WEIGHT	COMPTS, COUNT	PCT DIG.	PCT ANAL.	PCT E/M	PCT PS	PCT XMTR	PCT SS	POWER DIS.	BIT /FIT	UTIL. FACTOR	QPA	PCT NRTS
1)71820	13721.	443.	17.7	410.	0.	86.	14.	0.	0.	86.	200.	0.	2.30	1.	13.
2)71H60	36913.	1676.	30.6	78.	0.	24.	76.	0.	0.	24.	820.	0.	2.30	1.	16.
3)71L80	6681.	1444.	40.0	491.	0.	75.	0.	0.	25.	27.	212.	0.	2.30	1.	27.

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MODEL OUTPUTS

	COMP DENSITY	NO OF ** SPARES **	TOT LSC PER OH	FLD LSC PER OH (W/NRTS)	DEPOT REP COST	TRN PER OH	MTBF	MTBMA	TOT MMHOH (W/NRTS)	UNS MMHOH	SHOP MMHOH (W/NRTS)	NRTS
1)	.93	42.0 **	.652	.508	1126.	.190	509.	309.	.0367	.0143	.0250	.1300
2)	.05	43.0 **	.780	.520	2285.	.574	533.	357.	.0430	.0139	.0282	.1600
3)	.34	109.0 **	1.098	.906	1194.	.344	185.	137.	.0994	.0289	.0699	.2700
SUBSYSTEM TOTALS =			2.530	2.004	4604.	1.107	108.	75.	.1896	.0571	.1299	

	ANNUAL LSC	ANNUAL TNG COST	ANNUAL SE COST	TOTAL ANN. COST	SPARES COST	SE COST
1)	201286.	58573.	263279.	523137.	576282.	2632785.
2)	241040.	177194.	708287.	1126529.	1587259.	7082866.
3)	339289.	106128.	128195.	573612.	728229.	1281950.

TOTAL ANNUAL COST FOR ALTERNATIVE 1 = 2223279.
TOTAL NON-RECURRING COST FOR ALTERNATIVE 1 = 13889372.

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LRU INPUT VARIABLES

TEST-3 FOR PHASE 2 REL.- NRTS USED IN LSC-FIELD,MMH-TOT,SHOP

IDENT. NUMBER	UNIT PRICE	VOLUME	WEIGHT	COMPTS. COUNT	PCT DIG.	PCT ANAL.	PCT E/M	PCT PS	PCT XMTR	PCT SS	POWER DIS.	BIT /FIT	UTIL. FACTOR	QPA	PCT NRTS
1)71B20	13721.	443.	17.7	410.	0.	86.	14.	0.	0.	86.	200.	0.	2.30	1.	13.
2)71H60	36913.	1676.	30.6	78.	0.	24.	76.	0.	0.	24.	820.	0.	2.30	1.	16.
3)71L80	6681.	1444.	40.0	491.	0.	75.	0.	0.	25.	27.	212.	0.	2.30	1.	27.

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SYSTEM INPUT VARIABLES

QUANTITY OF SYSTEMS	67
COMMAND	TAC
AVIONICS AREA	SENSORY
AIRCRAFT TYPE	FIGHTER
OP/HR PER A/C PER MONTH	21.0
NO OF SYS PER SQN/WING	75.
NUMBER OF ALTERNATIVES	2
ALTERNATIVE ONE LRUS	4
ALTERNATIVE TWO LRUS	2

...NOTE: ESTIMATING RELATIONSHIPS DEVELOPED IN PHASE 1 ARE BEING EXECUTED...

...CALCULATED VALUE OF NRTS FOR EACH LRU IS BEING USED...

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LRU INPUT VARIABLES

LRUS FROM APQ120 FOR VALIDATION - NOT IN REGRESSION DATA BASE

IDENT, NUMBER	UNIT PRICE	VOLUME	WEIGHT	COMPTS, COUNT	PCT DIG,	PCT ANAL,	PCT E/M	PCT PS	PCT XMTR	PCT SS	POWER DIS,	BIT /FIT	UTIL, FACTOR	QPA
1)748CO	8046,	585,	12.5	878,	0.	87,	13,	0,	0,	87,	58,	2,	2,30	1,
2)748EO	3398,	324,	9.3	58,	0,	0,	0,	100,	0,	100,	75,	0,	2,30	1,
3)748GO	9831,	563,	11,8	209,	0,	77,	23,	0,	0,	77,	24,	15,	2,30	1,
4)748HO	9910,	777,	40,8	73,	0,	72,	28,	0,	0,	69,	1800,	6,	2,30	1,

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MODEL OUTPUTS

	COMP DENSITY	NO OF SPARES	**	LSC PER OH	TRN PER OH	MTBF	MTBMA	MMHOH	NRTS	ANNUAL LSC	ANNUAL TNG COST	ANNUAL SE COST	TOTAL ANN. COST	SPARES COST	SE COST
1)	1.50	6.0	**	.295	.124	821.	446.	.0251	0.0030	11462.	4828.	19407.	35697.	0.	194070.
2)	.18	0.0	**	.091	.009	1091.	648.	0.0000	0.0030	3530.	332.	8196.	12057.	0.	81960.
3)	.37	4.0	**	.131	.035	785.	545.	.0112	.3377	5101.	1341.	23712.	30155.	35324.	237124.
4)	.89	3.0	**	.160	.050	334.	361.	.1091	.1726	8205.	1930.	23903.	32038.	29730.	239029.

TOTAL ANNUAL COST FOR ALTERNATIVE 1 = 109948.
TOTAL NON-RECURRING COST FOR ALTERNATIVE 1 = 821236.

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LRU INPUT VARIABLES

LRUS FROM APQ 120 USED IN REGRESSION ANALYSIS

IDENT. NUMBER	UNIT PRICE	VOLUME	WEIGHT	COMPTS. COUNT	PCT DIG.	PCT ANAL.	PCT E/M	PCT PS	PCT XMTR	PCT SS	POWER DIS.	BIT /FIT	UTIL. FACTOR	QPA
1)74BDO	10120.	1609.	43.7	1126.	0.	61.	39.	0.	0.	61.	212.	0.	2.30	1.
2)74BFO	15250.	1377.	78.5	399.	0.	0.	0.	0.	100.	98.	900.	1.	2.30	1.

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MODEL OUTPUTS

	COMP DENSITY	NO OF ** SPARES **	LSC PER OH	TRN PER OH	MTBF	MTBMA	MMHOH	NRTS	ANNUAL LSC	ANNUAL TNG COST	ANNUAL SE COST	TOTAL ANN. COST	SPARES COST	SE COST
1)	.70	0.0 **	.800	1.000	316.	193.	.0673	0.0000	31078.	41958.	24409.	97438.	0.	244094.
2)	.29	8.0 **	.853	.400	233.	120.	.0437	.2144	33128.	15543.	36802.	85473.	122064.	368023.

TOTAL ANNUAL COST FOR ALTERNATIVE 2 = 182911.
TOTAL NON-RECURRING COST FOR ALTERNATIVE 2 = 734181.

PREDICTIVE AVIONICS D & M COST MODEL
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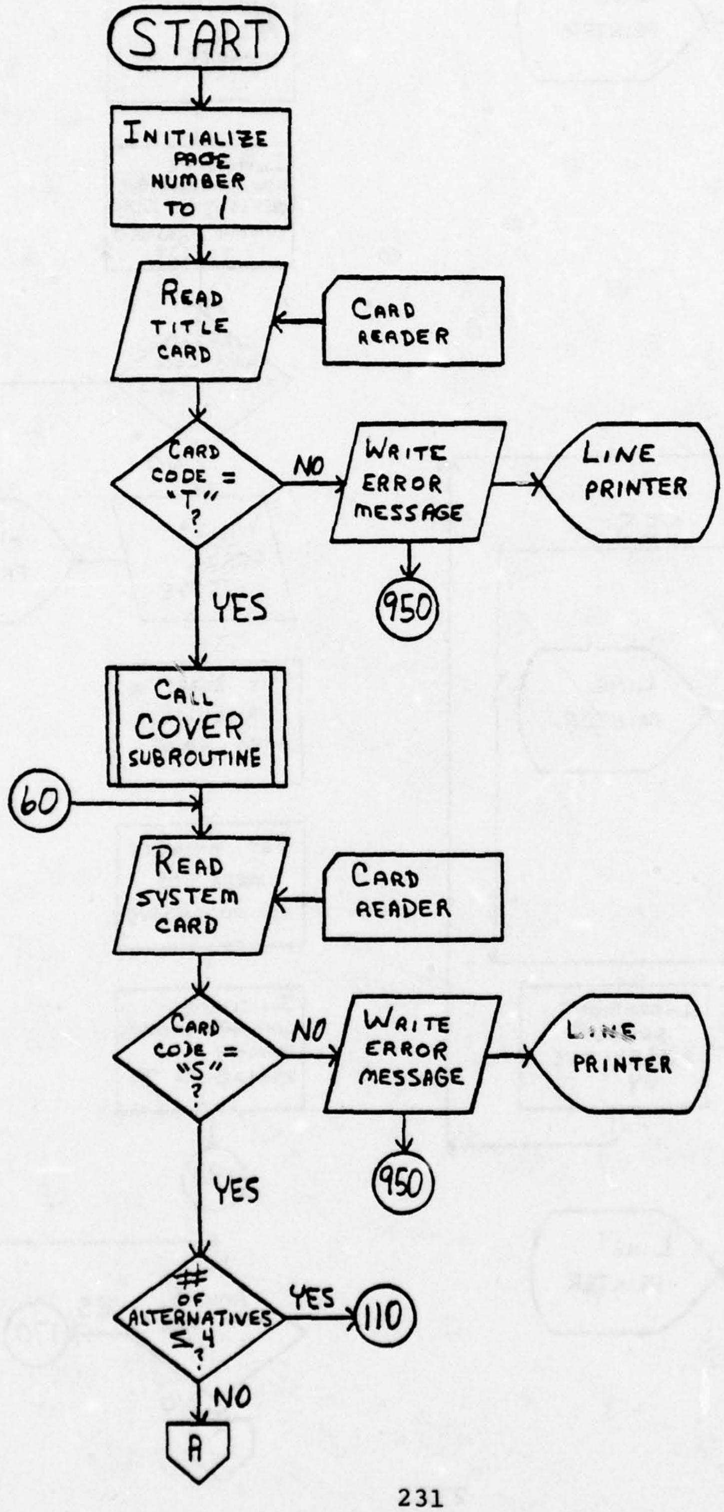
SYSTEM INPUT VARIABLES

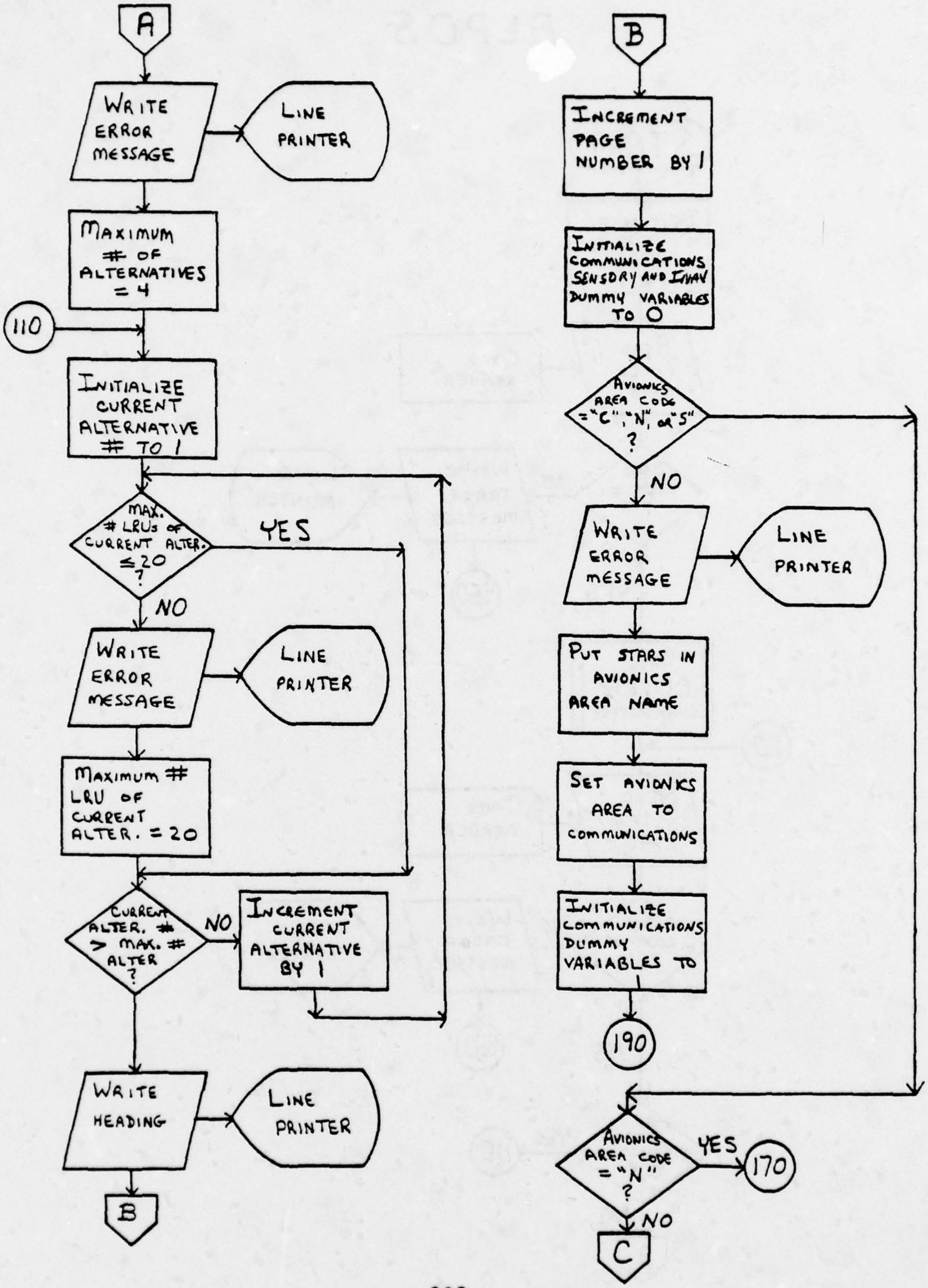
QUANTITY OF SYSTEMS	80
COMMAND	TAC
AVIONICS AREA	COMMUNICATIONS
AIRCRAFT TYPE	FIGHTER
OP/HR PER A/C PER MONTH	21.0
NO OF SYS PER SQN/WING	75.
NUMBER OF ALTERNATIVES	1
ALTERNATIVE ONE LRUS	1

...ERROR...CERSET HAS AN UNACCEPTABLE VALUE...

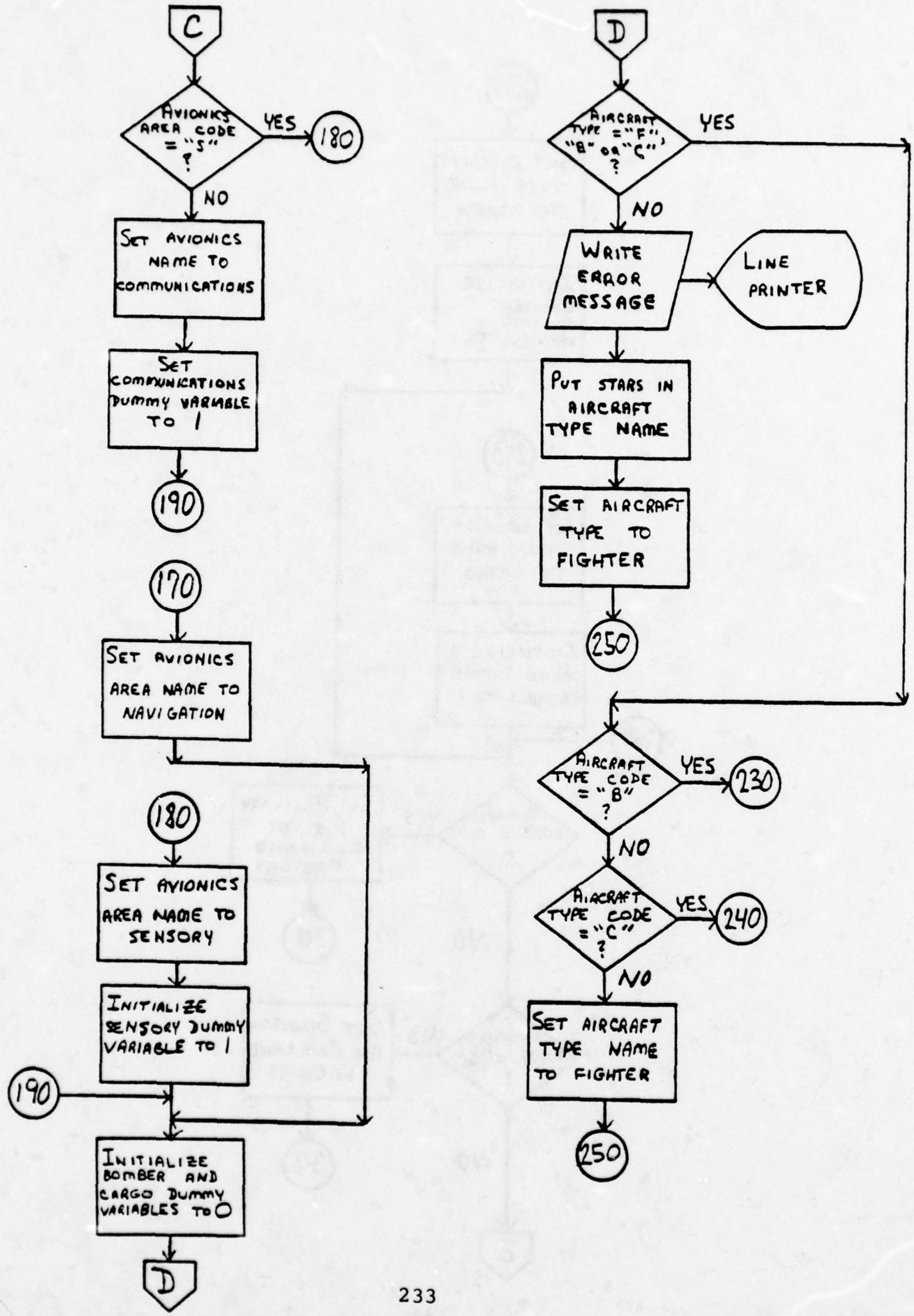
............NOT A 1 OR A 2...PROGRAM IS TERMINATED

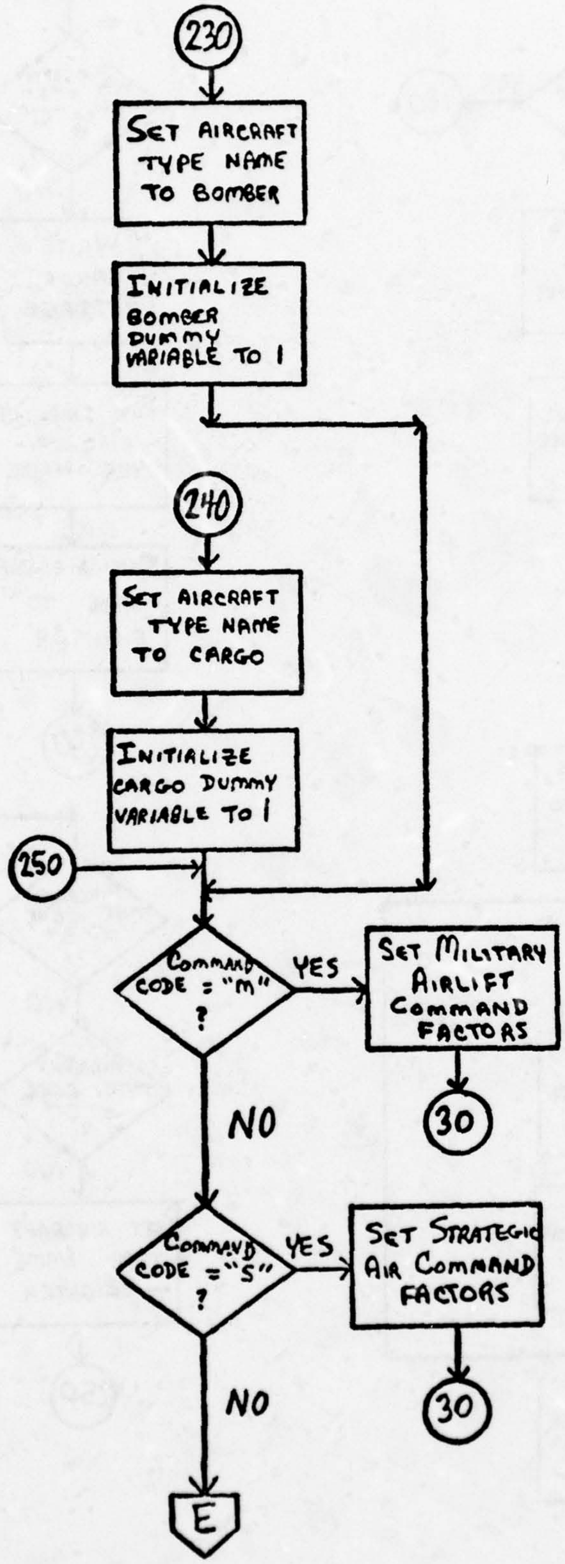
ALPOS

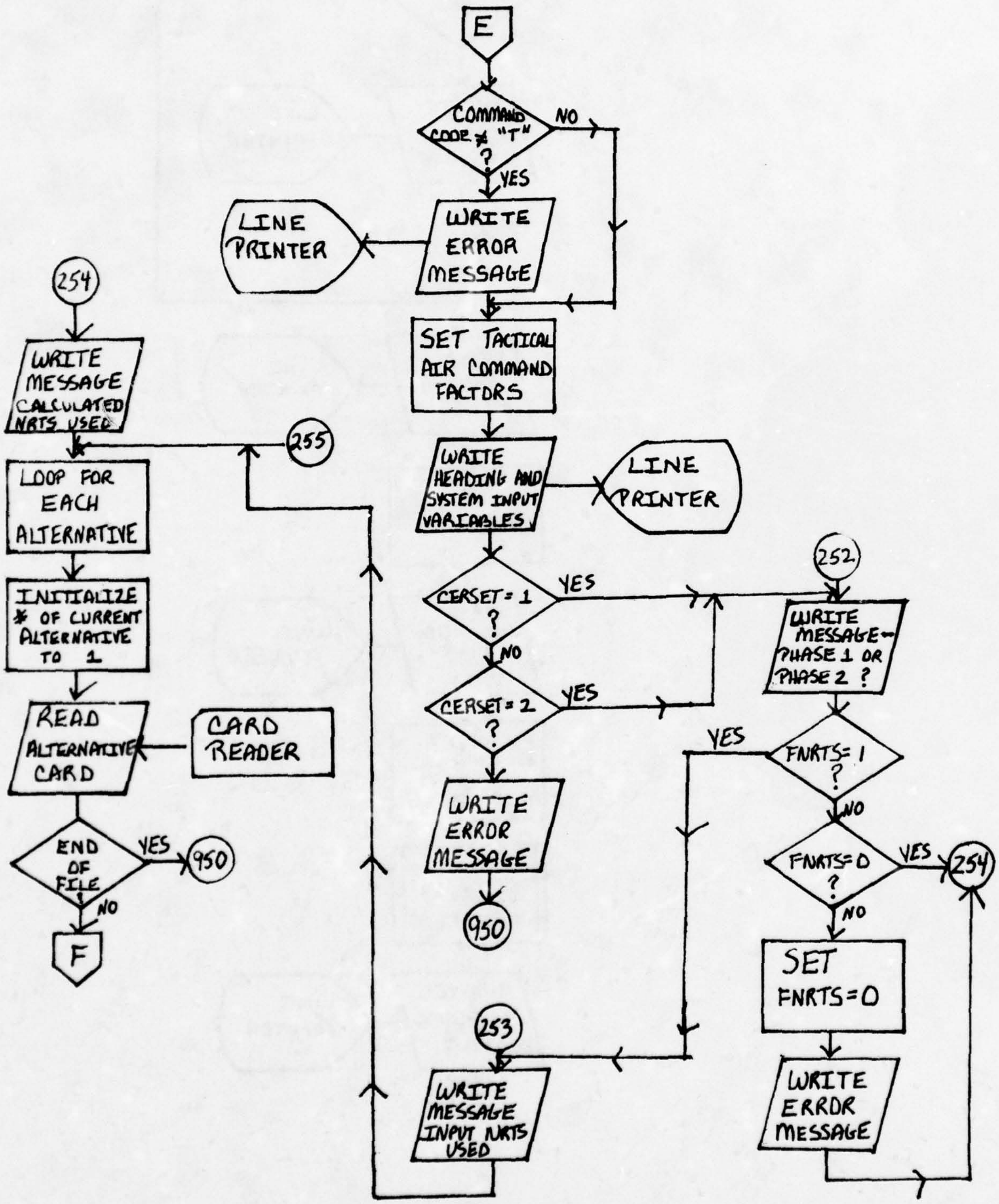

START
INITIALIZE PAGE NUMBER TO 1
READ TITLE CARD
CARD READER
CARD CODE = "T" ?
NO
WRITE ERROR MESSAGE
LINE PRINTER
950
YES
CALL COVER SUBROUTINE
60
READ SYSTEM CARD
CARD READER
CARD CODE = "S" ?
NO
WRITE ERROR MESSAGE
LINE PRINTER
950
YES
OF ALTERNATIVES ≤ 4 ?
YES
110
NO
A

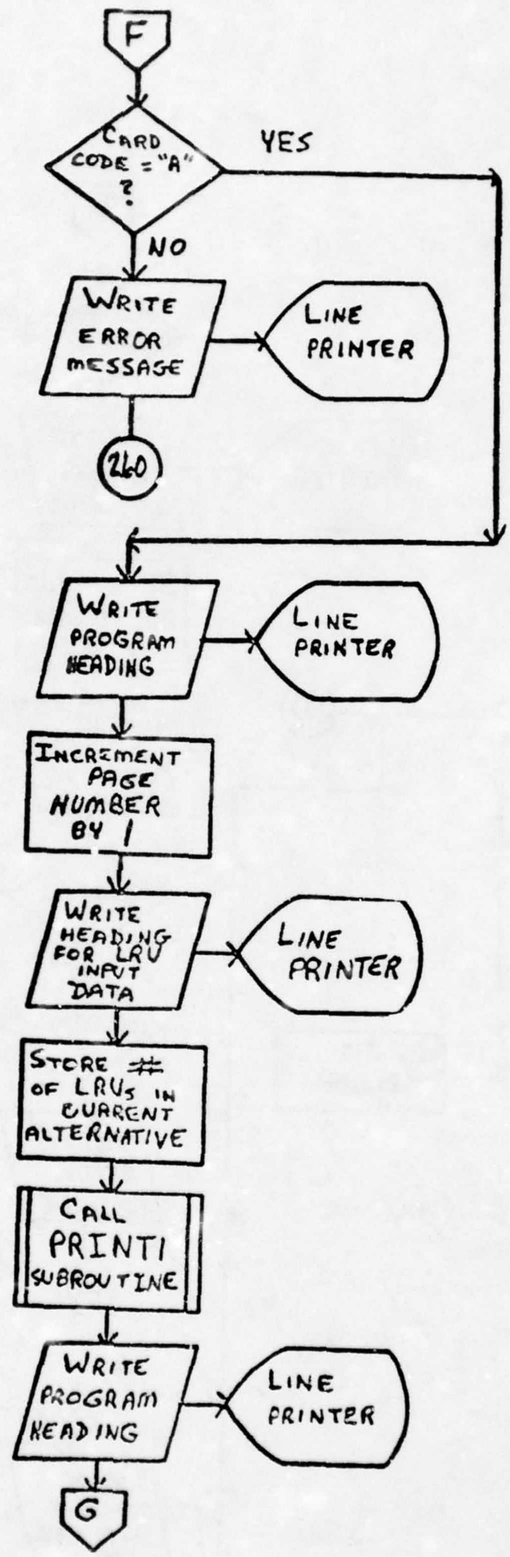


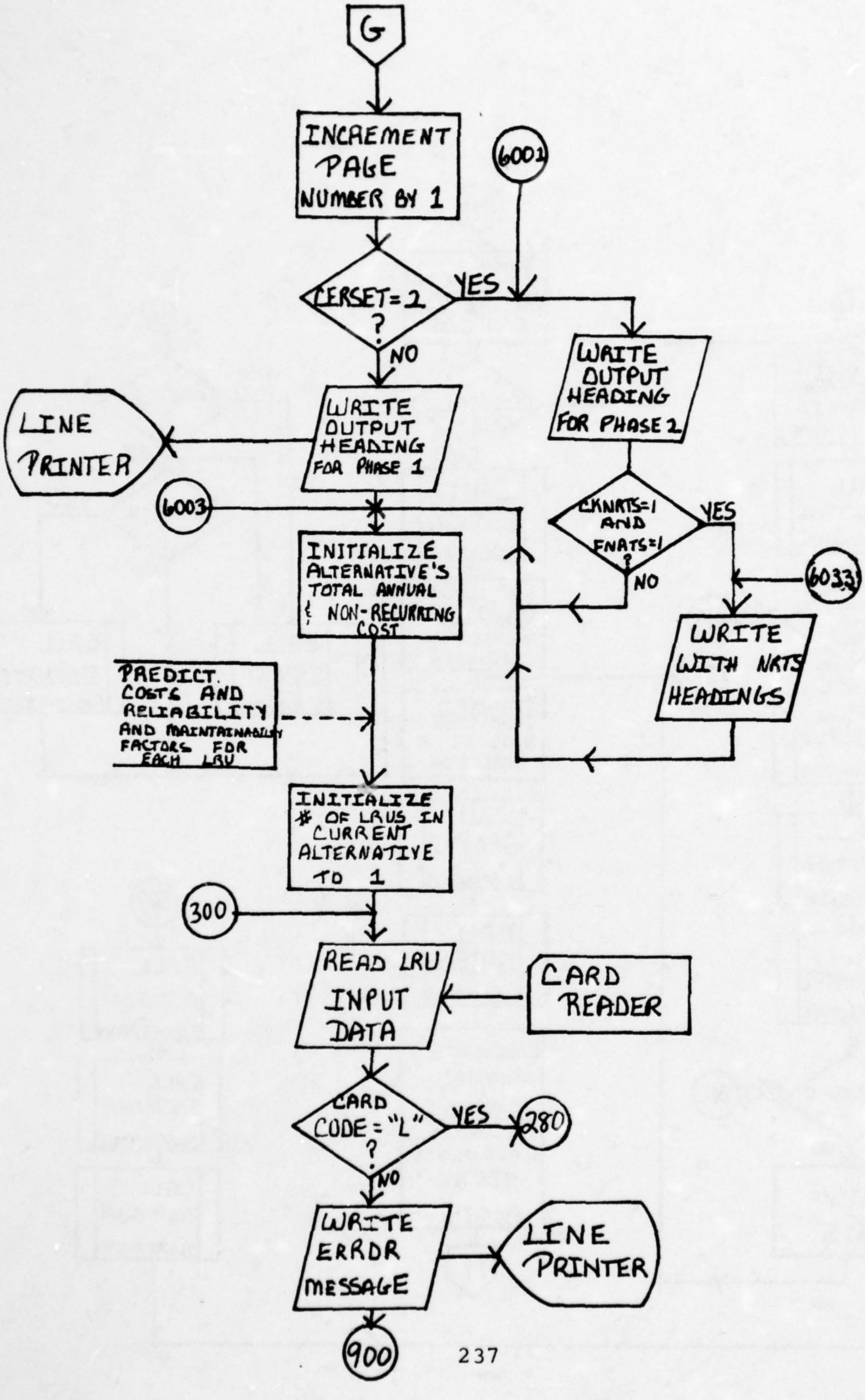
A
WRITE ERROR MESSAGE
LINE PRINTER
MAXIMUM # OF ALTERNATIVES = 4
110
INITIALIZE CURRENT ALTERNATIVE # TO 1
MAX. # LRUs OF CURRENT ALTER. ≤ 20 ?
YES
NO
WRITE ERROR MESSAGE
LINE PRINTER
MAXIMUM # LRU OF CURRENT ALTER. = 20
CURRENT ALTER. # > MAX. # ALTER ?
NO
INCREMENT CURRENT ALTERNATIVE BY 1
WRITE HEADING
LINE PRINTER
B
B
INCREMENT PAGE NUMBER BY 1
INITIALIZE COMMUNICATIONS SENSORY AND INAV DUMMY VARIABLES TO 0
AVIONICS AREA CODE = "C", "N", OR "S" ?
NO
WRITE ERROR MESSAGE
LINE PRINTER
PUT STARS IN AVIONICS AREA NAME
SET AVIONICS AREA TO COMMUNICATIONS
INITIALIZE COMMUNICATIONS DUMMY VARIABLES TO 1
190
AVIONICS AREA CODE = "N" ?
YES
170
NO
C


C
AVIONICS AREA CODE = "S" ?
YES
180
NO
SET AVIONICS NAME TO COMMUNICATIONS
SET COMMUNICATIONS DUMMY VARIABLE TO 1
190
170
SET AVIONICS AREA NAME TO NAVIGATION
180
SET AVIONICS AREA NAME TO SENSORY
INITIALIZE SENSORY DUMMY VARIABLE TO 1
190
INITIALIZE BOMBER AND CARGO DUMMY VARIABLES TO 0
D
D
AIRCRAFT TYPE = "F", "B" OR "C" ?
YES
NO
WRITE ERROR MESSAGE
LINE PRINTER
PUT STARS IN AIRCRAFT TYPE NAME
SET AIRCRAFT TYPE TO FIGHTER
250
AIRCRAFT TYPE CODE = "B" ?
YES
230
NO
AIRCRAFT TYPE CODE = "C" ?
YES
240
NO
SET AIRCRAFT TYPE NAME TO FIGHTER
250

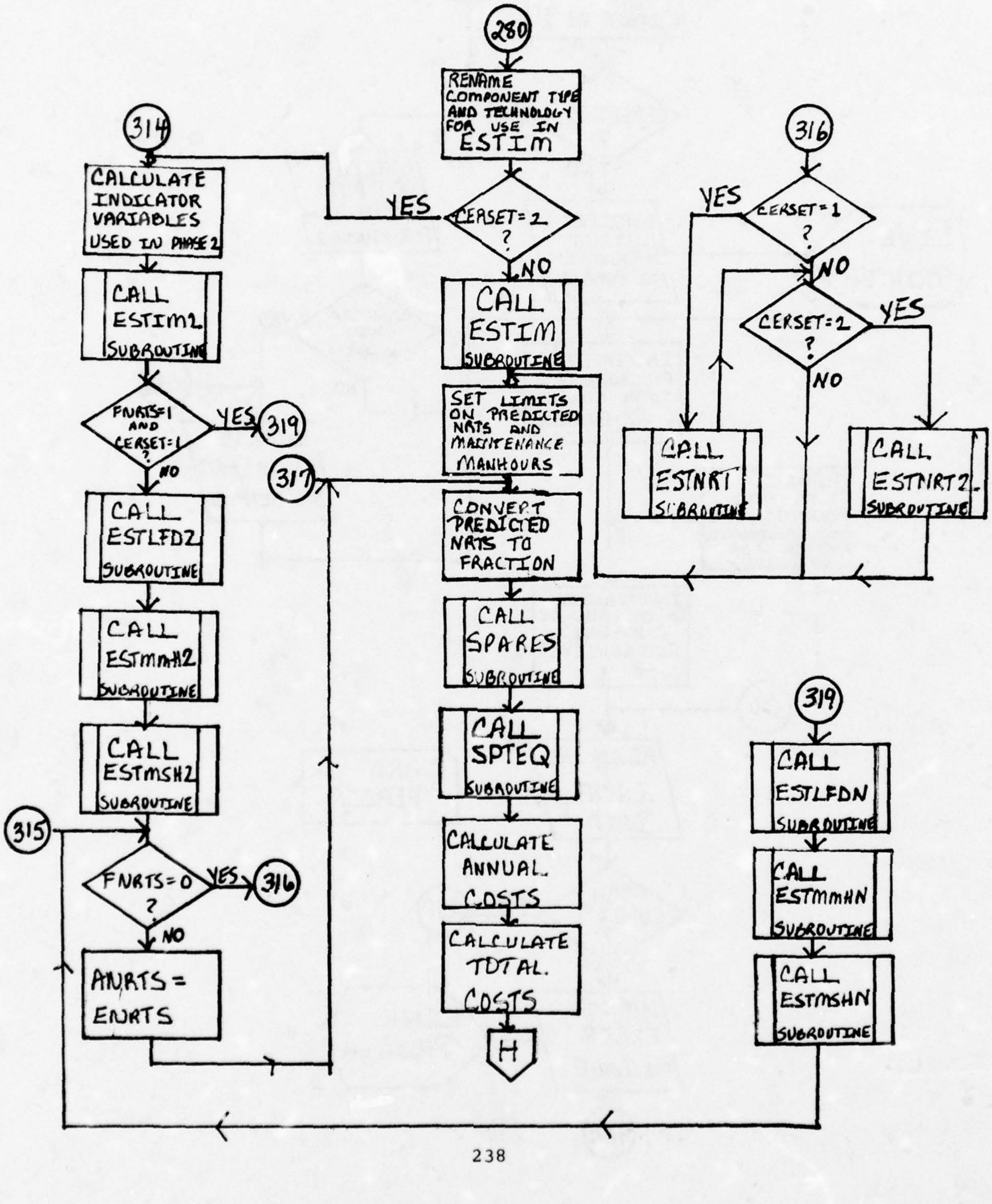

230
SET AIRCRAFT TYPE NAME TO BOMBER
INITIALIZE BOMBER DUMMY VARIABLE TO 1
240
SET AIRCRAFT TYPE NAME TO CARGO
INITIALIZE CARGO DUMMY VARIABLE TO 1
250
COMMAND CODE = "M" ?
YES
SET MILITARY AIRLIFT COMMAND FACTORS
30
NO
COMMAND CODE = "S" ?
YES
SET STRATEGIC AIR COMMAND FACTORS
30
NO
E

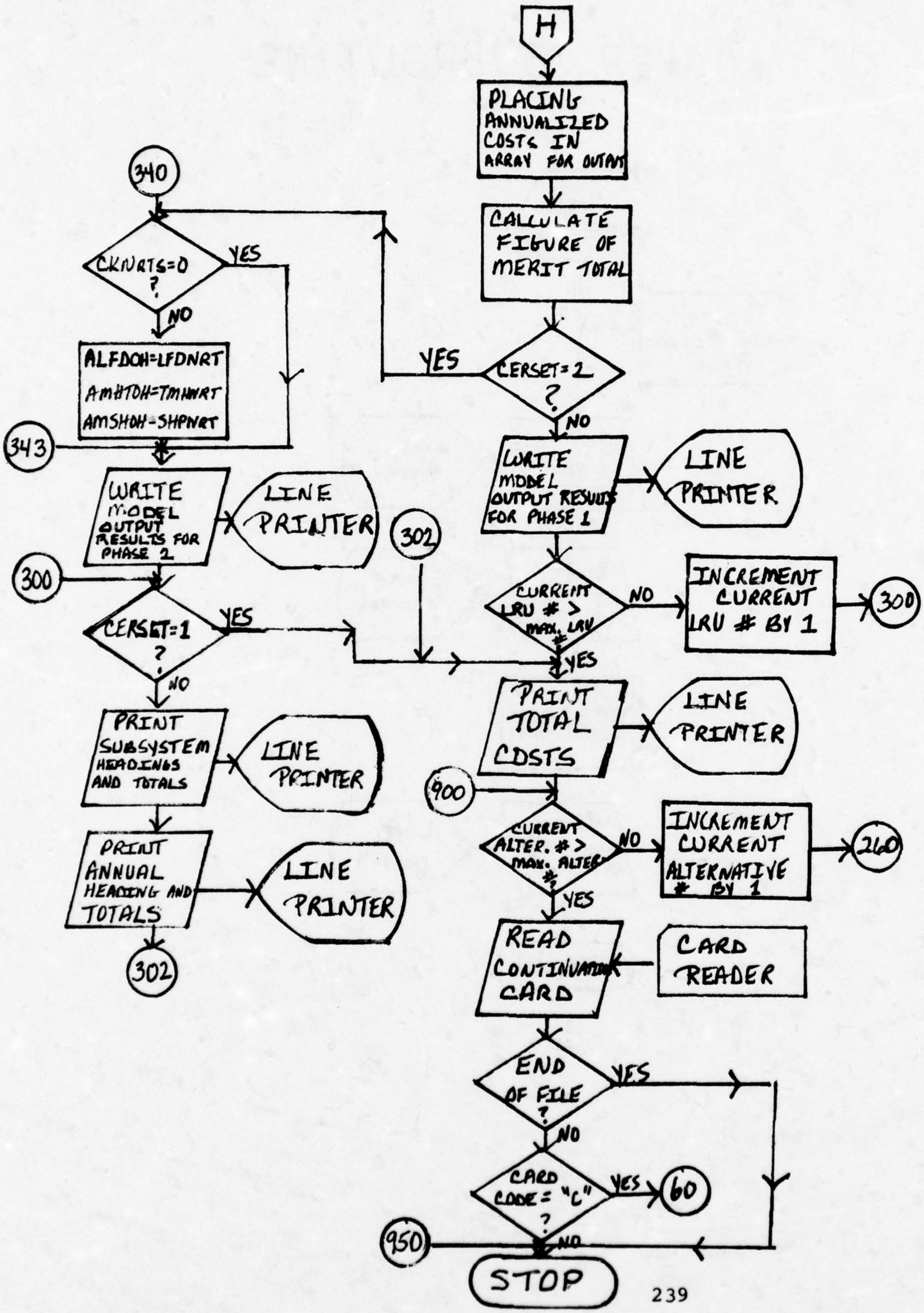

E
COMMAND CODE ≠ "T" ?
NO
YES
WRITE ERROR MESSAGE
LINE PRINTER
SET TACTICAL AIR COMMAND FACTORS
WRITE HEADING AND SYSTEM INPUT VARIABLES
LINE PRINTER
CERSET = 1 ?
YES
NO
CERSET = 2 ?
YES
WRITE ERROR MESSAGE
950
252
WRITE MESSAGE — PHASE 1 OR PHASE 2 ?
FNRTS = 1 ?
YES
NO
FNRTS = 0 ?
YES
254
NO
SET FNRTS = 0
WRITE ERROR MESSAGE
253
WRITE MESSAGE INPUT NRTS USED
254
WRITE MESSAGE CALCULATED NRTS USED
255
LOOP FOR EACH ALTERNATIVE
INITIALIZE # OF CURRENT ALTERNATIVE TO 1
READ ALTERNATIVE CARD
CARD READER
END OF FILE
YES
950
NO
F


F
CARD CODE = "A" ?
YES
NO
WRITE ERROR MESSAGE
LINE PRINTER
260
WRITE PROGRAM HEADING
LINE PRINTER
INCREMENT PAGE NUMBER BY 1
WRITE HEADING FOR LRU INPUT DATA
LINE PRINTER
STORE # OF LRUs IN CURRENT ALTERNATIVE
CALL PRINTI SUBROUTINE
WRITE PROGRAM HEADING
LINE PRINTER
G

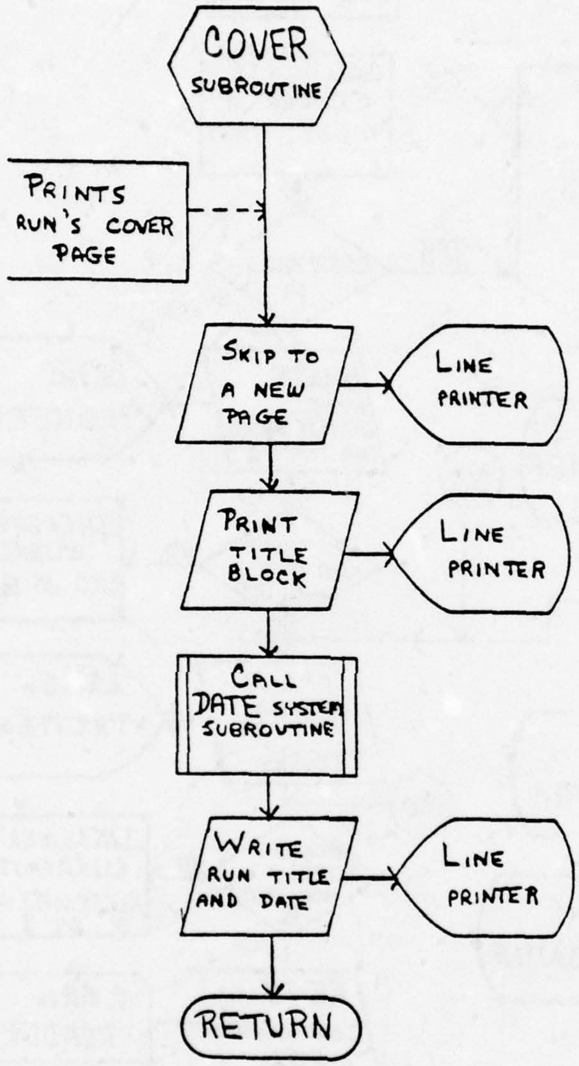


G
INCREMENT PAGE NUMBER BY 1
6001
CERSET=2 ?
YES
NO
WRITE OUTPUT HEADING FOR PHASE 2
LINE PRINTER
WRITE OUTPUT HEADING FOR PHASE 1
6003
CKNRTS=1 AND FNRTS=1 ?
YES
NO
6033
INITIALIZE ALTERNATIVE'S TOTAL ANNUAL & NON-RECURRING COST
WRITE WITH NRTS HEADINGS
PREDICT COSTS AND RELIABILITY AND MAINTAINABILITY FACTORS FOR EACH LRU
INITIALIZE # OF LRUS IN CURRENT ALTERNATIVE TO 1
300
READ LRU INPUT DATA
CARD READER
CARD CODE = "L" ?
YES
280
NO
WRITE ERROR MESSAGE
LINE PRINTER
900

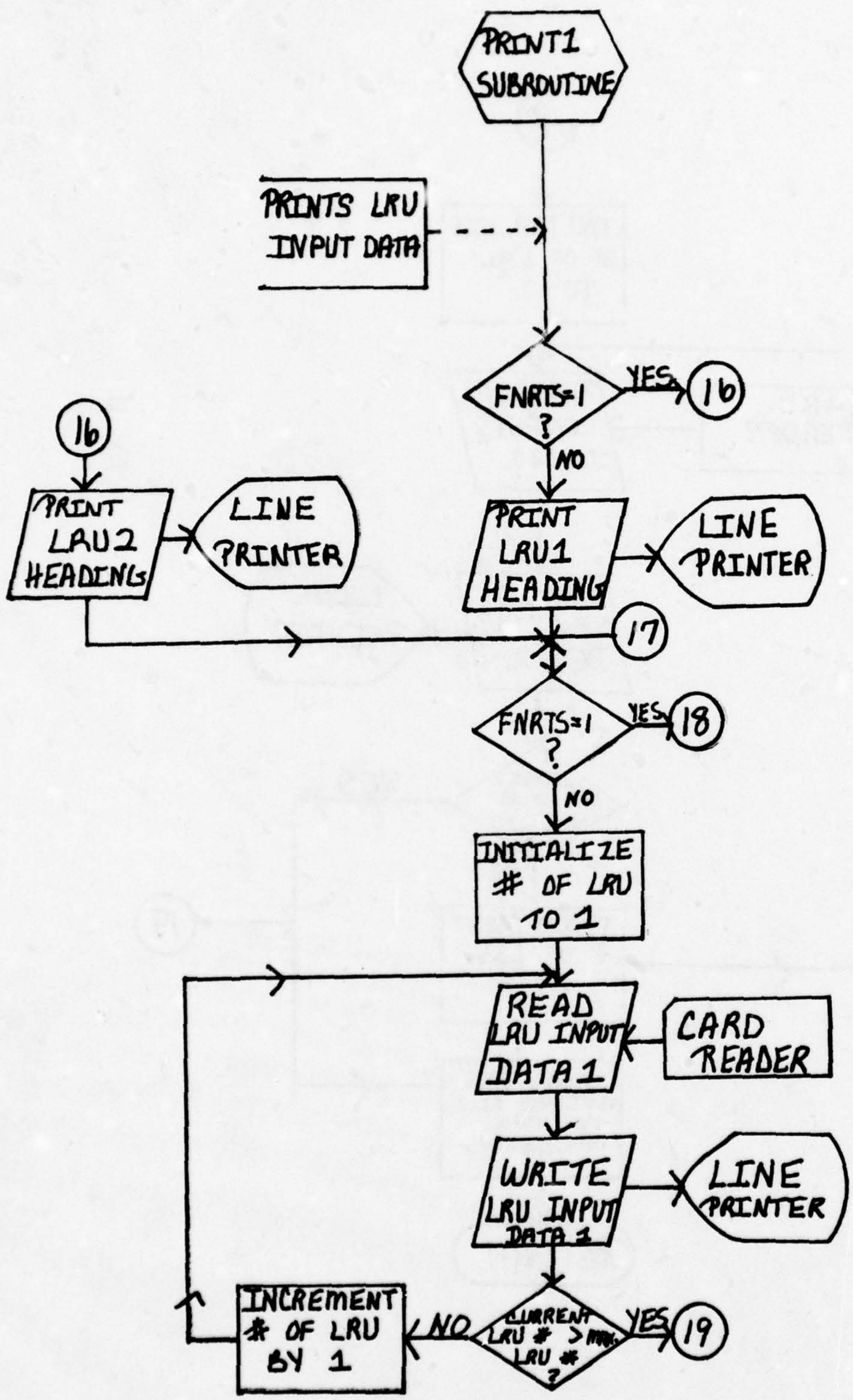

280
RENAME COMPONENT TYPE AND TECHNOLOGY FOR USE IN ESTIM
CERSET = 2 ?
YES
NO
CALL ESTIM SUBROUTINE
SET LIMITS ON PREDICTED NRTS AND MAINTENANCE MANHOURS
CONVERT PREDICTED NRTS TO FRACTION
CALL SPARES SUBROUTINE
CALL SPTEQ SUBROUTINE
CALCULATE ANNUAL COSTS
CALCULATE TOTAL COSTS
H
314
CALCULATE INDICATOR VARIABLES USED IN PHASE 2
CALL ESTIM2 SUBROUTINE
FNRTS=1 AND CERSET=1 ?
YES
319
NO
CALL ESTLFD2 SUBROUTINE
CALL ESTMMH2 SUBROUTINE
CALL ESTMSH2 SUBROUTINE
315
FNRTS = 0 ?
YES
316
NO
ANRTS = ENRTS
317
316
CERSET = 1 ?
YES
NO
CERSET = 2 ?
YES
NO
CALL ESTNRT SUBROUTINE
CALL ESTNRT2 SUBROUTINE
319
CALL ESTLFDN SUBROUTINE
CALL ESTMMHN SUBROUTINE
CALL ESTMSHN SUBROUTINE


H
PLACING ANNUALIZED COSTS IN ARRAY FOR OUTPUT
CALCULATE FIGURE OF MERIT TOTAL
CERSET=2 ?
YES
NO
340
CKNRTS=0 ?
YES
NO
ALFDOH=LFDNRT
AMHTOH=TMHNRT
AMSHOH=SHPNRT
343
WRITE MODEL OUTPUT RESULTS FOR PHASE 2
LINE PRINTER
WRITE MODEL OUTPUT RESULTS FOR PHASE 1
LINE PRINTER
302
300
CERSET=1 ?
YES
NO
CURRENT LRU # > MAX. LRU # ?
NO
YES
INCREMENT CURRENT LRU # BY 1
300
PRINT SUBSYSTEM HEADINGS AND TOTALS
LINE PRINTER
PRINT TOTAL COSTS
LINE PRINTER
900
CURRENT ALTER. # > MAX. ALTER #
NO
YES
INCREMENT CURRENT ALTERNATIVE # BY 1
260
PRINT ANNUAL HEADING AND TOTALS
LINE PRINTER
302
READ CONTINUATION CARD
CARD READER
END OF FILE ?
YES
NO
CARD CODE = "C" ?
YES
60
NO
950
STOP

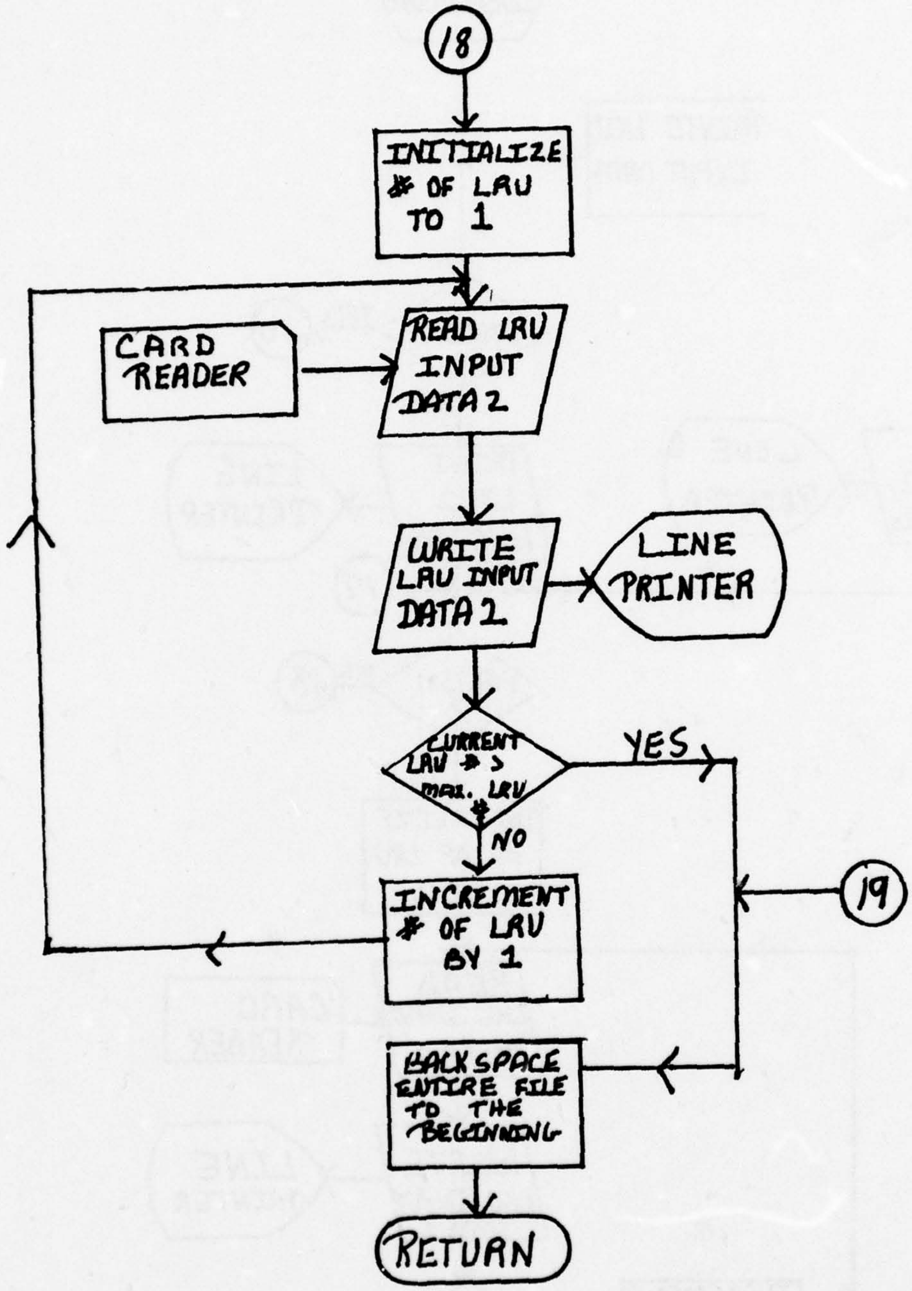
COVER SUBROUTINE



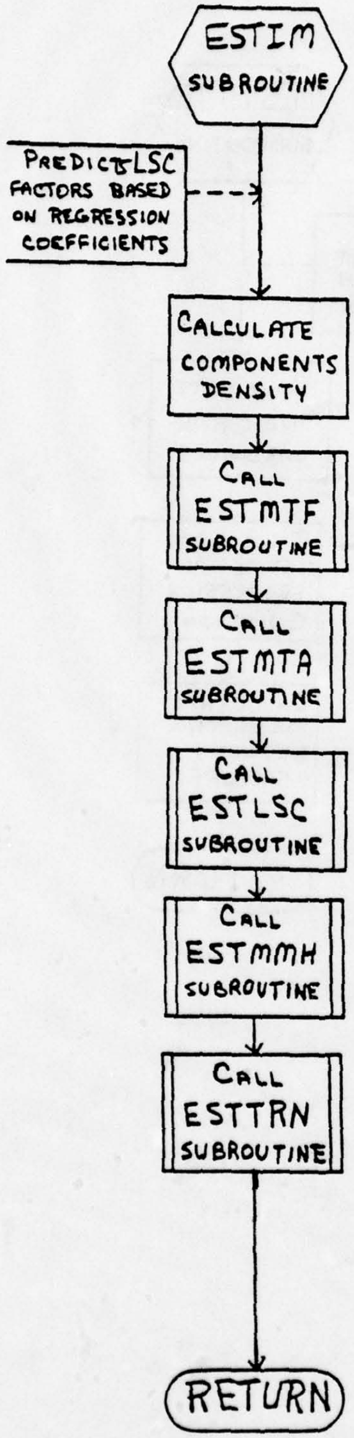
PRINT1 SUBROUTINE



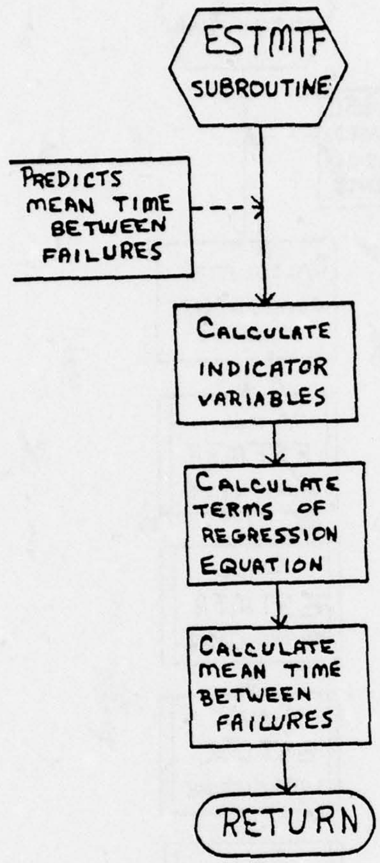
PRINT1 SUBROUTINE CONTINUED



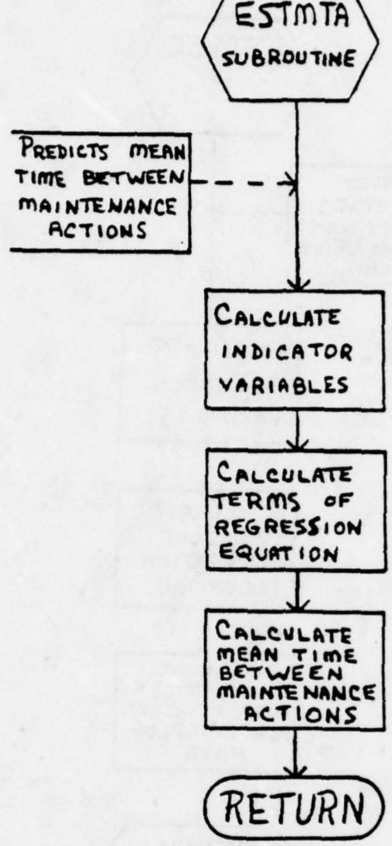
ESTIM SUBROUTINE



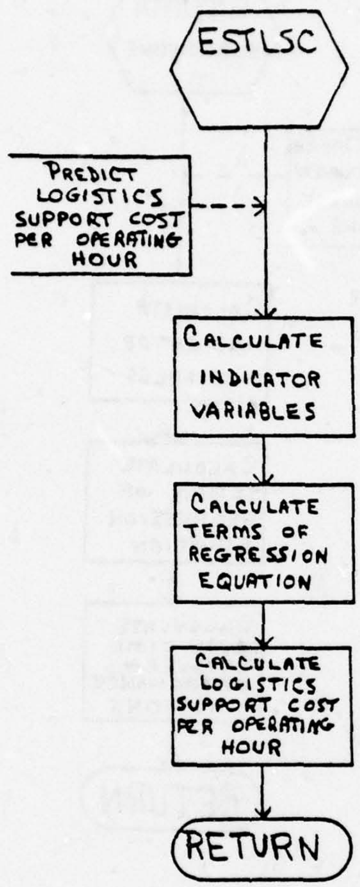
ESTMTF SUBROUTINE



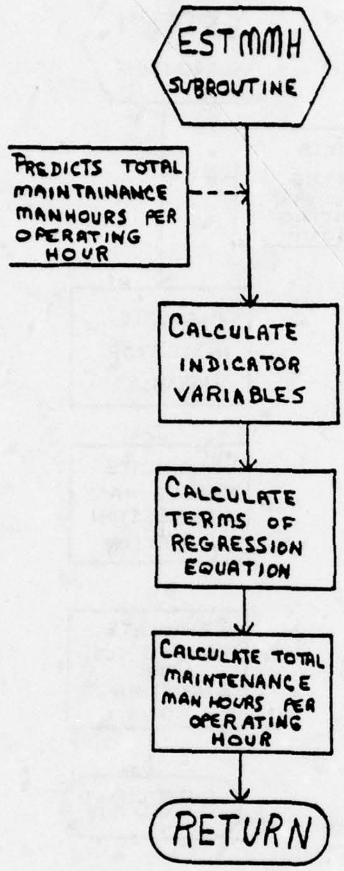
ESTMTA SUBROUTINE



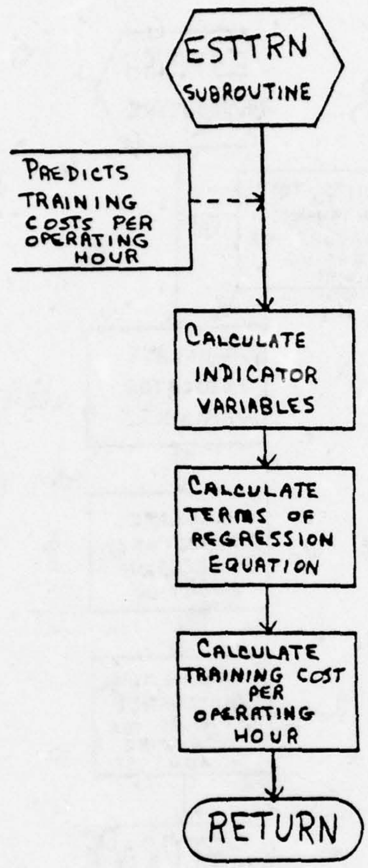
ESTLSC SUBROUTINE



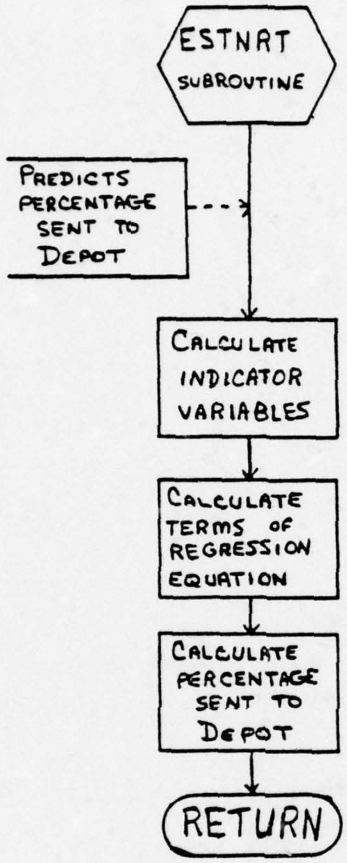
ESTMMH SUBROUTINE



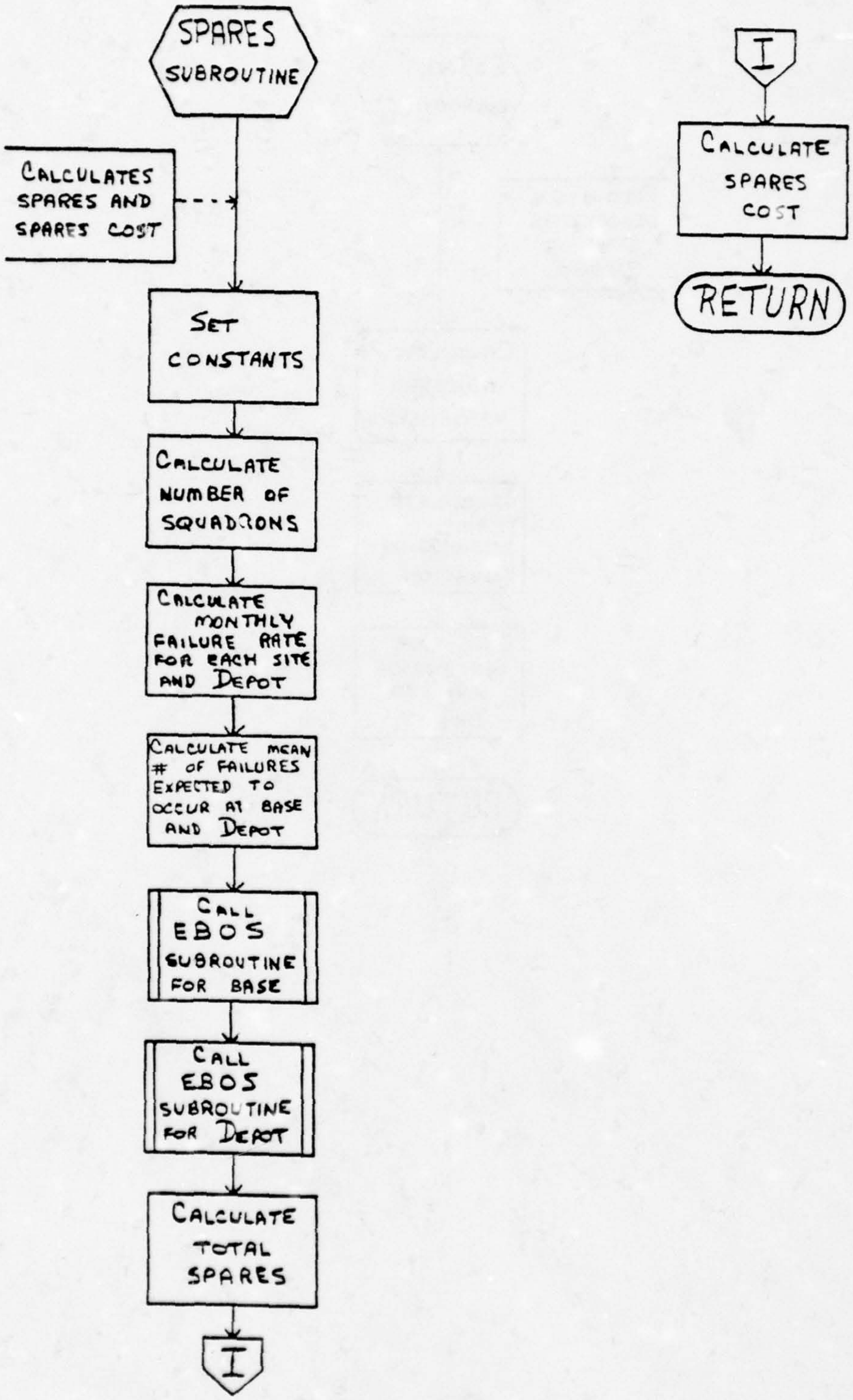
ESTTRN SUBROUTINE



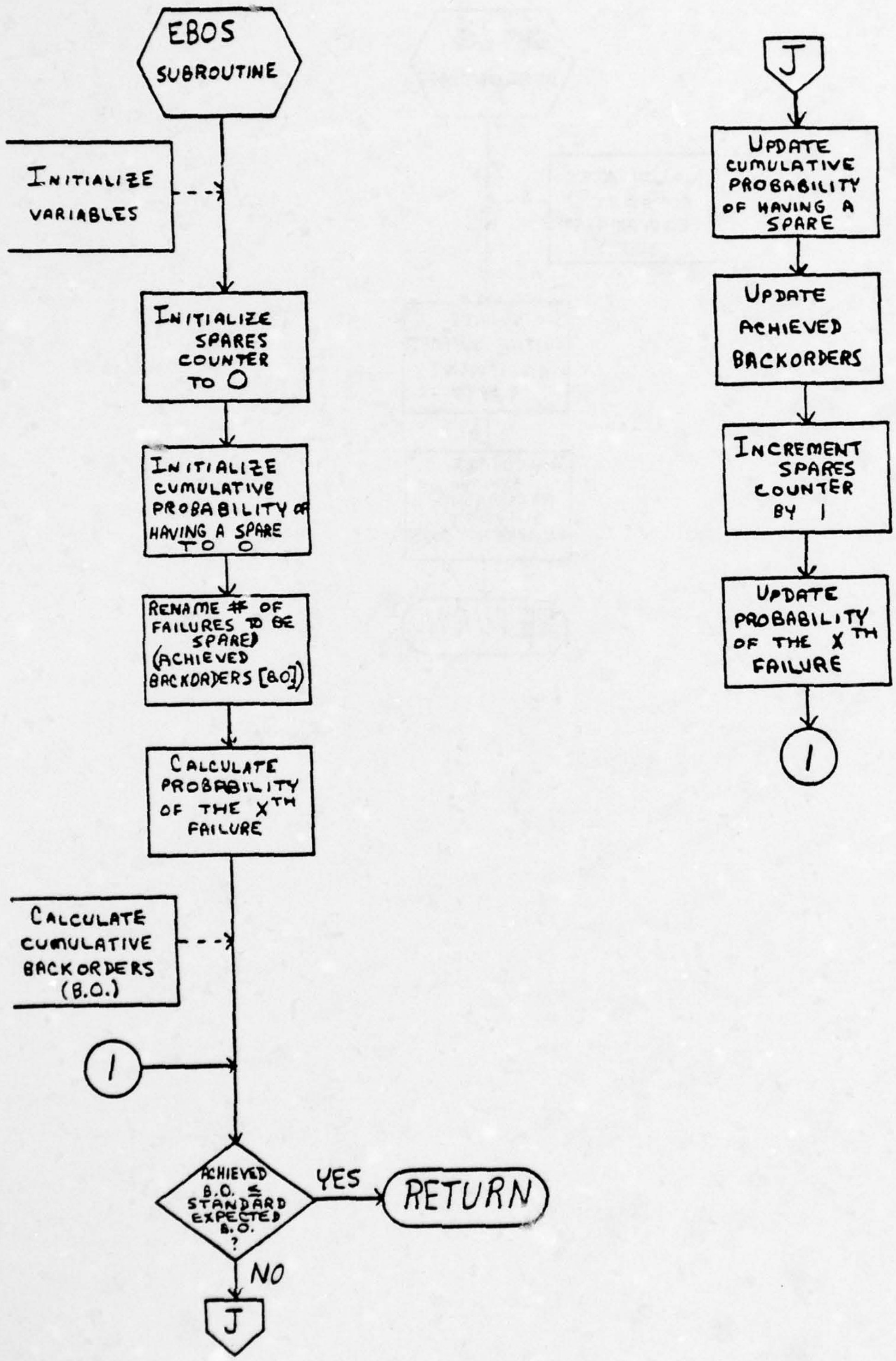
ESTNRT SUBROUTINE



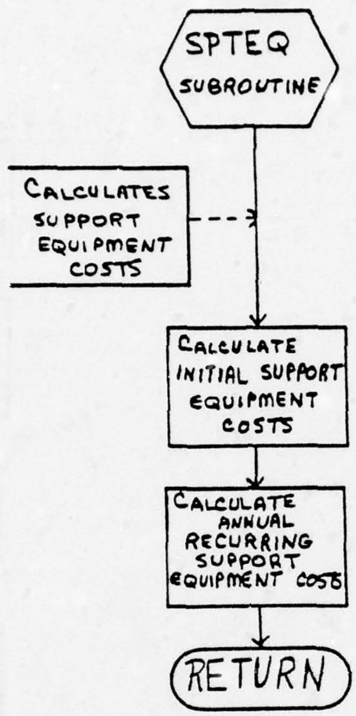
SPARES SUBROUTINE



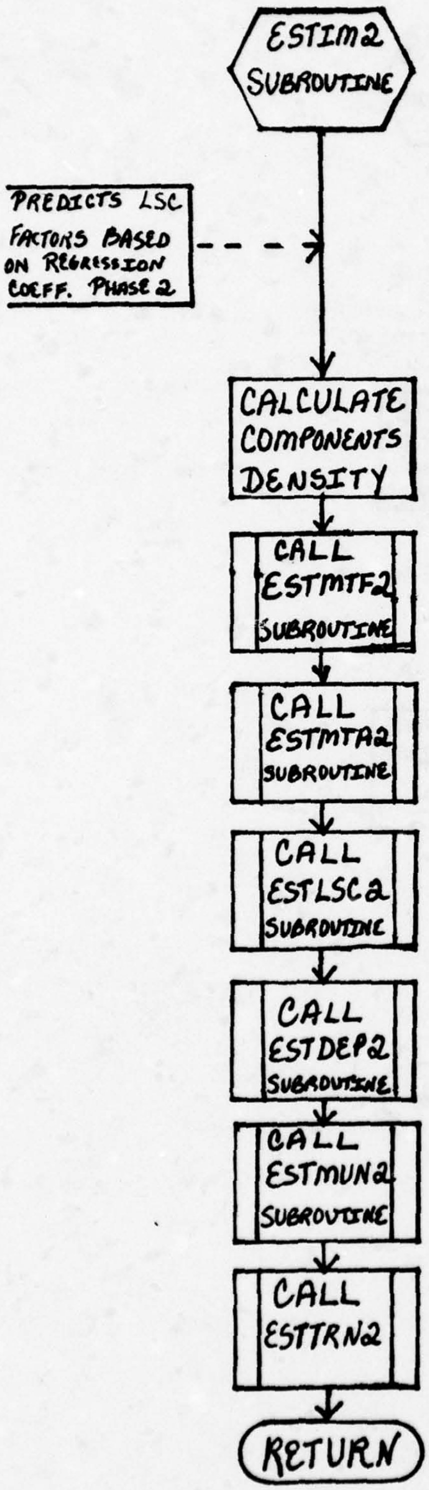
EBOS SUBROUTINE



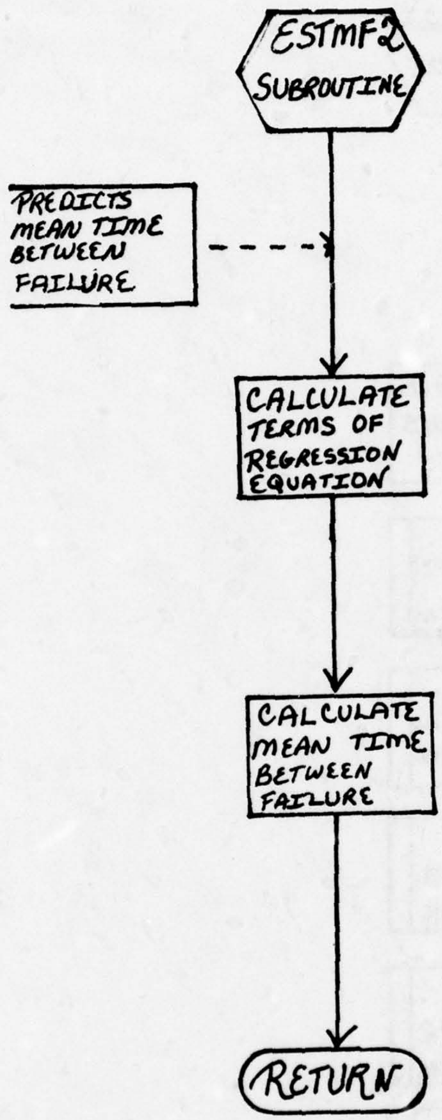
SPTEQ SUBROUTINE



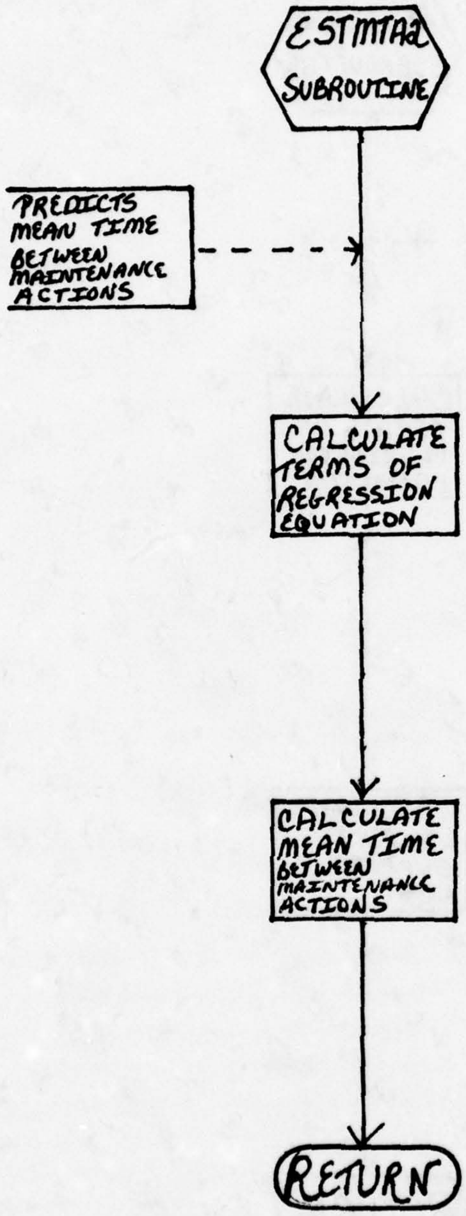
ESTIM.2 SUBROUTINE



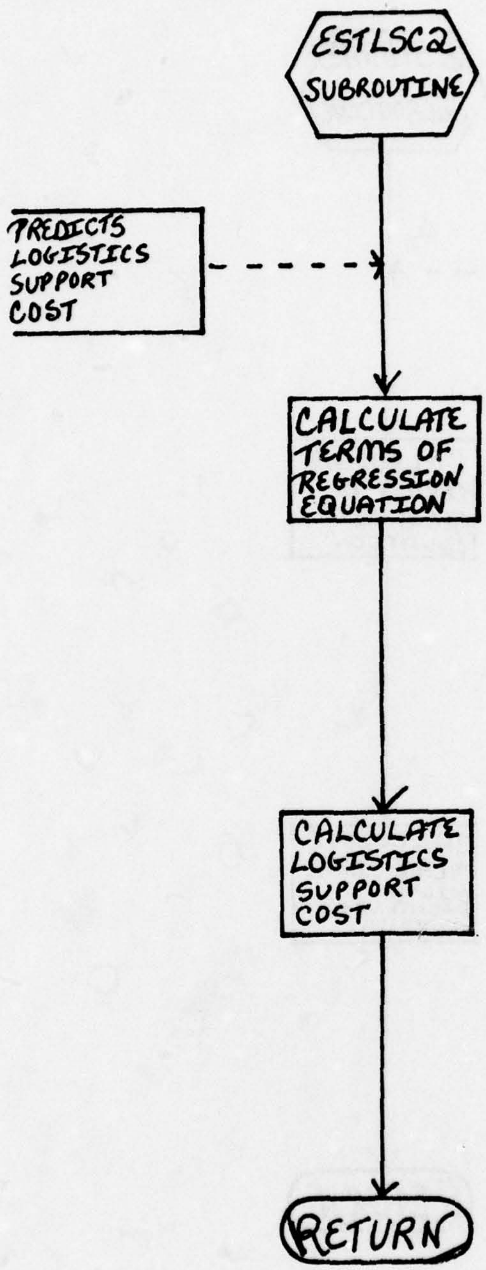
ESTMTF2 SUBROUTINE



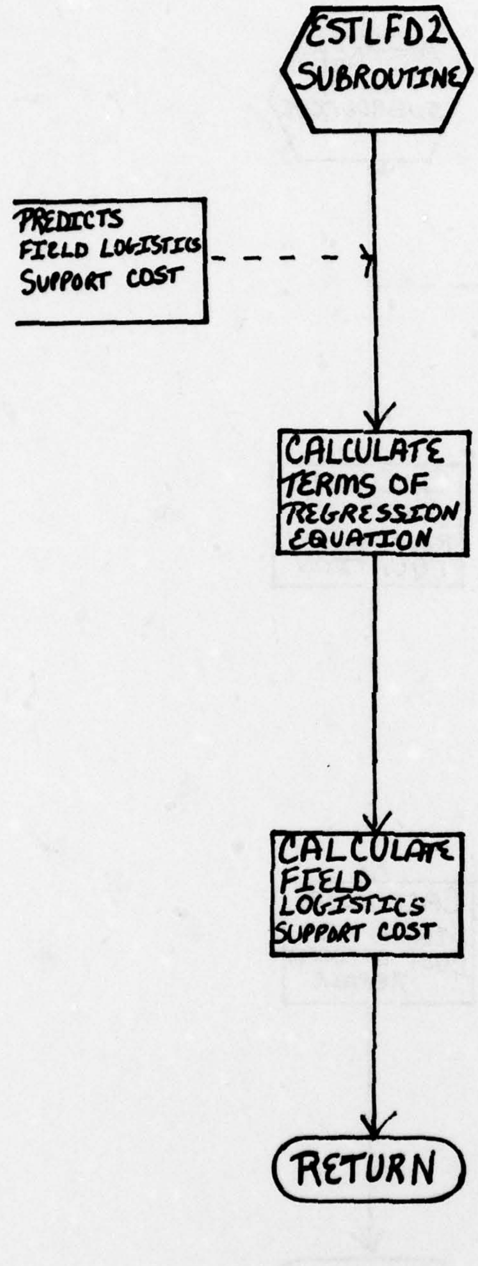
ESTMTA2 SUBROUTINE



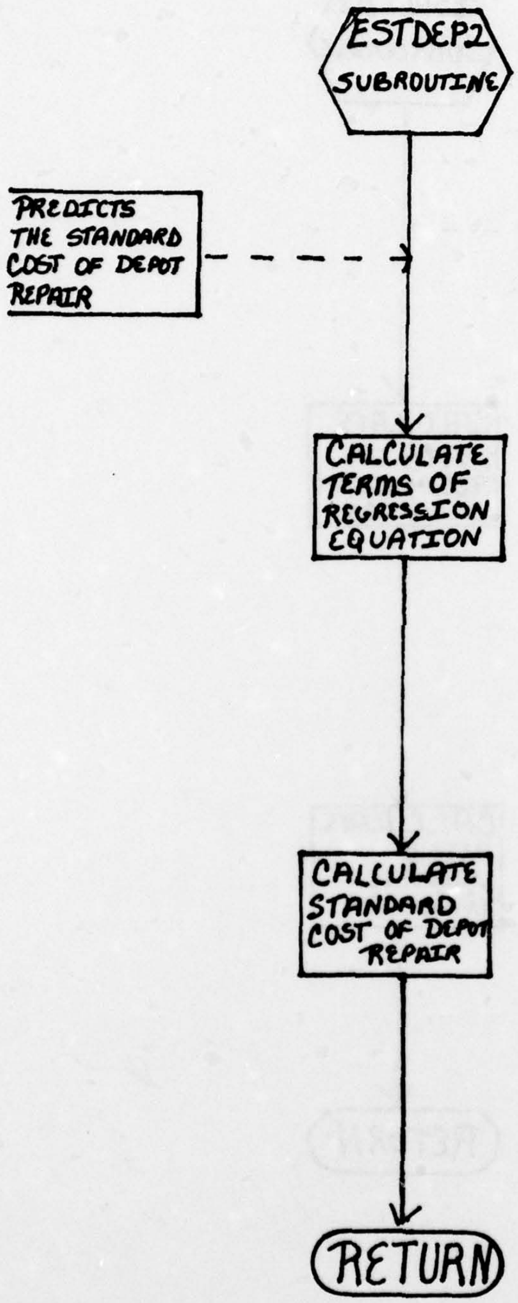
ESTLSC2 SUBROUTINE



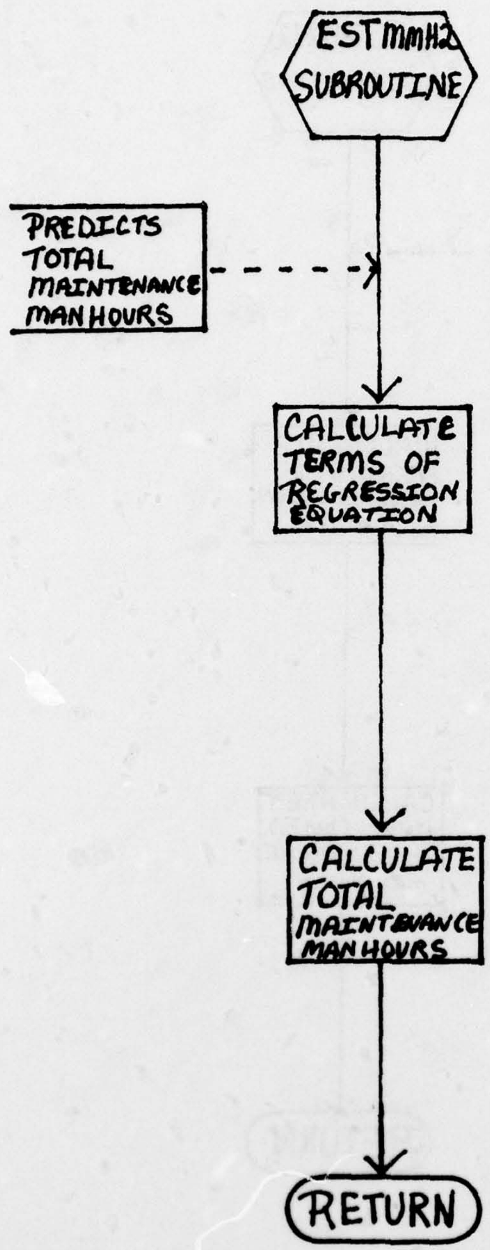
ESTLFD2 SUBROUTINE



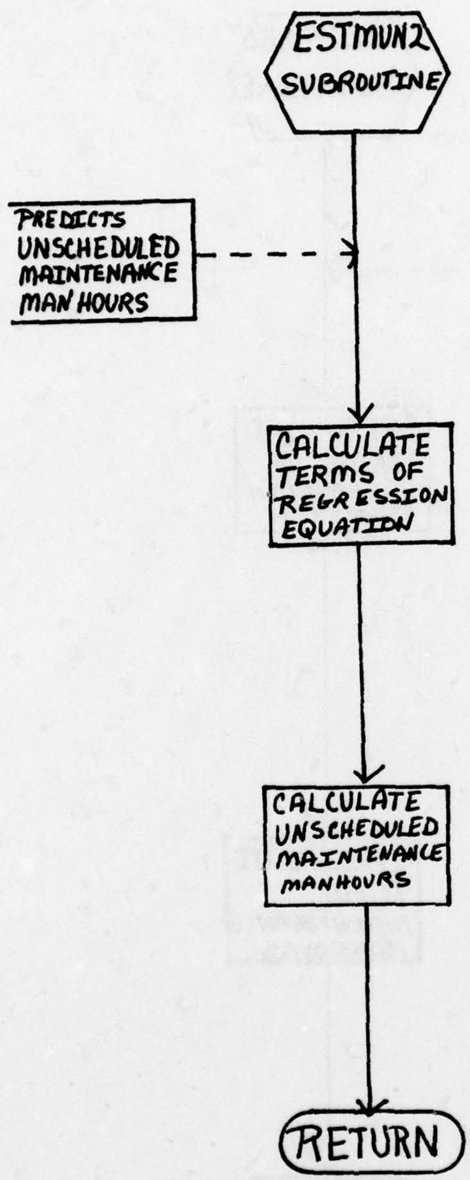
ESTDEP2 SUBROUTINE



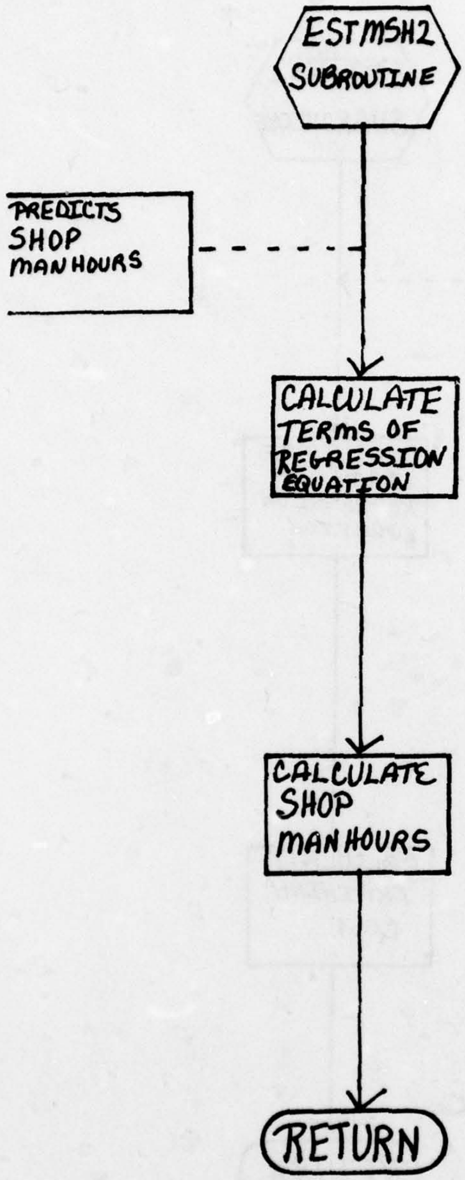
ESTMMH2 SUBROUTINE



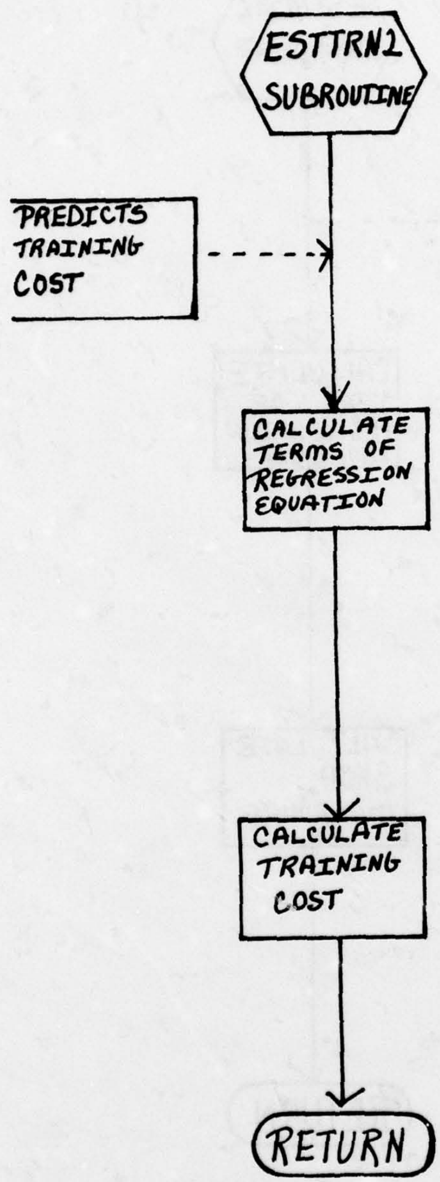
ESTMUN2 SUBROUTINE



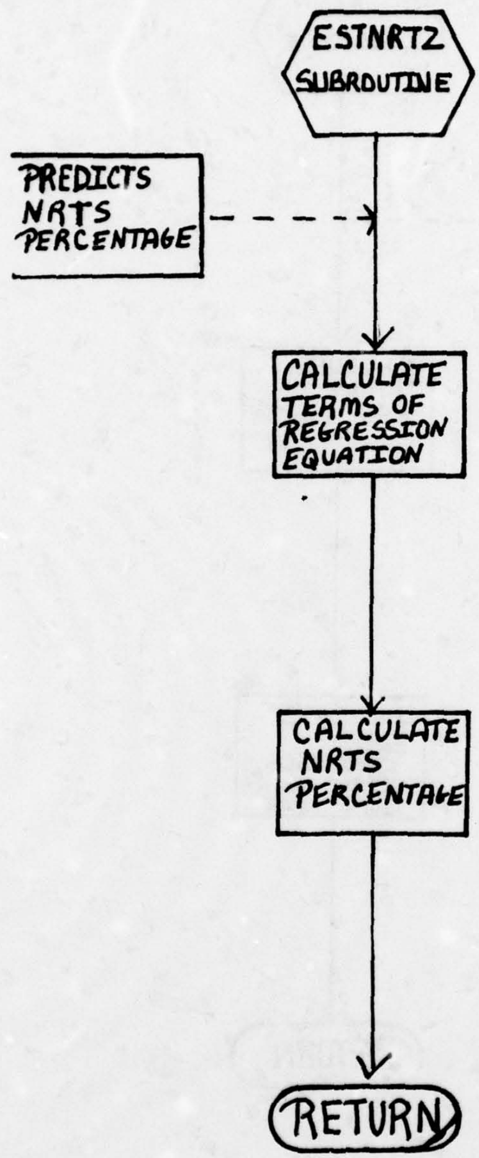
ESTMSH2 SUBROUTINE



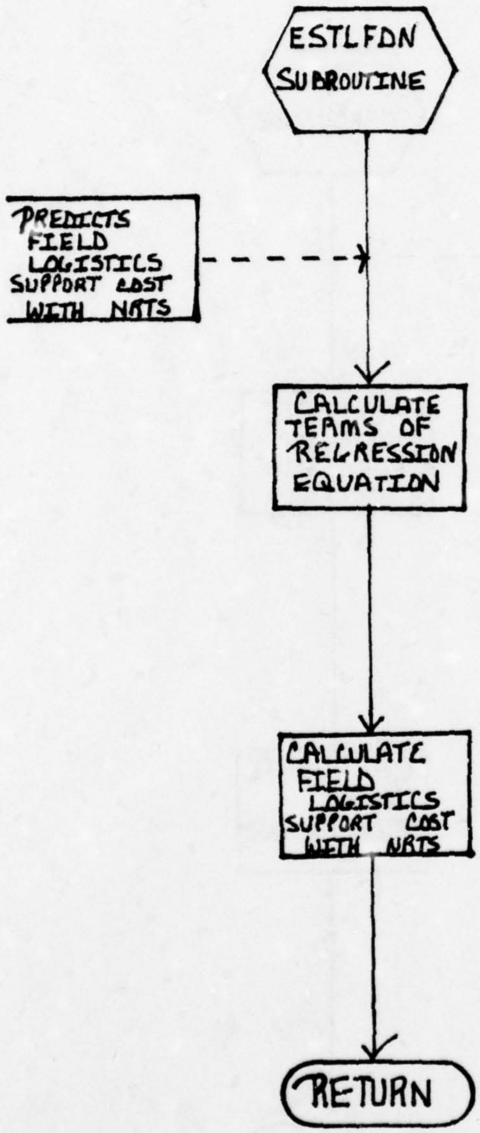
ESTTRN2 SUBROUTINE



ESTNRTZ SUBROUTINE



ESTLFDN SUBROUTINE



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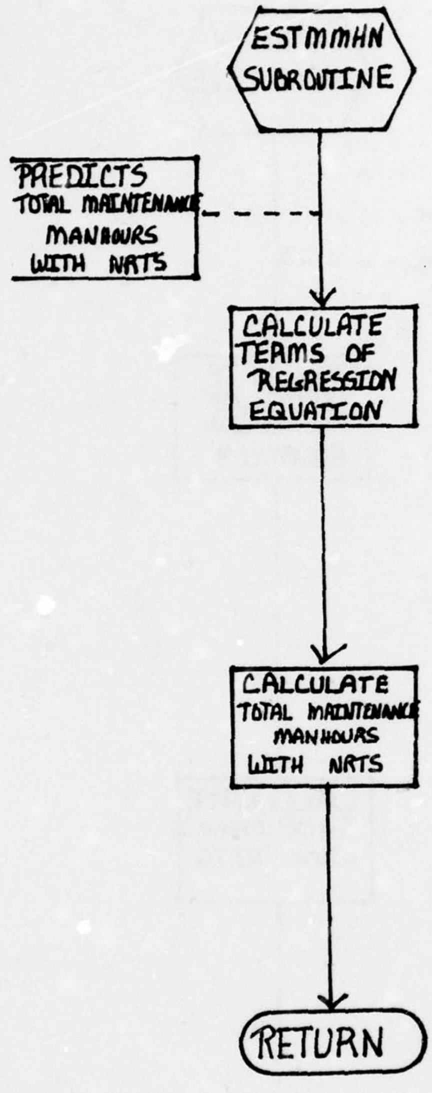
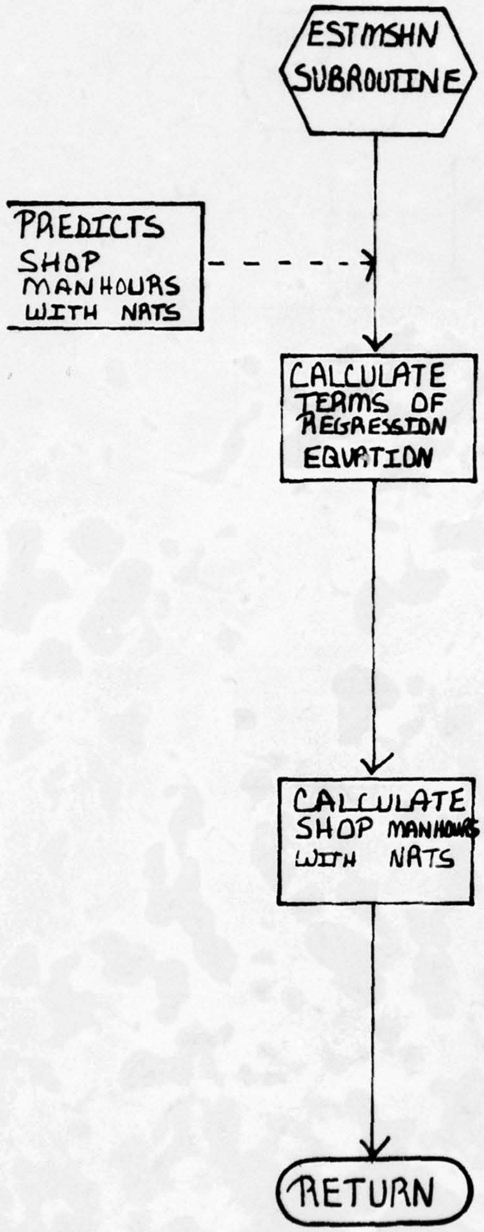


ESTMSHN SUBROUTINE



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